2.0 WORKING GROUPS

2.2 Current Working Groups— The Executive Committee Reporter for each working group will present an update on working group activities and progress, and will make recommendations on actions to be taken. Working groups expire at each General Meeting, but can be renewed at the meeting and can be disbanded whenever appropriate.

2.3 Working Group Proposals

2.1 Disbanded Working Groups

2.1.1 WG 122: Estuarine Sediment Dynamics (with LOICZ and IAPSO) (2003)

Terms of Reference:

- Collect and analyze global data on sediment retention in estuaries versus export to the coastal ocean, based on climate, hydrologic, physical, geological, chemical, and biological, and human processes, and including estuarine systems of different types, from tropical to subpolar.
- Evaluate available models of estuarine sediment retention.
- Identify research, observation (including standard measurement procedures), and modeling activities needed to improve predictions of sediment retention in estuaries.
- Conduct the above three TORs through WG meetings and an international workshop of interested scientists.
- Document the work of the WG and the workshop through a Web-based database of river/estuary sediment characteristics and trapping efficiencies, a special issue of a peer-reviewed journal, and a short article written for research managers and policymakers.

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Executive Committee Reporter: Bjørn Sundby

Volume 87, issue 2, 10 April 2010

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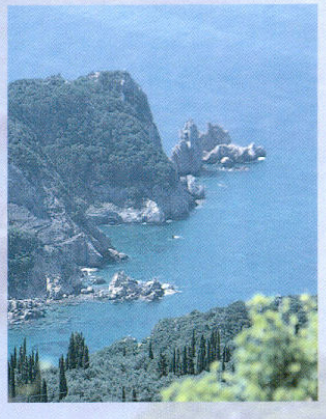
ESTUARINE COASTAL AND SHELF SCIENCE

in association with
the Estuarine and Coastal Sciences Association



Special Section

Mechanisms of Sediment Retention in Estuaries

Gerardo M. E. Perillo and James P. M. Syvitski
(Guest Editors)

ELSEVIER

Volume 87, issue 2, 10 April 2010

ESTUARINE COASTAL AND SHELF SCIENCE

CONTENTS

Abstracted/indexed in BIOBASE, BIOSIS databases/Zoological Records, CAB International, Chemical Abstracts Service, Current Awareness in Biological Sciences, Current Contents ASCA/Engineering Technology & Applied Science/Science, Citation Index/SCISEARCH Data, Current Contents/Agriculture, Biology & Environmental Sciences, Current Contents/Physics, Chemical, & Earth Sciences, Engineering Index, Environmental Periodicals Bibliography, Geo Bib & Index, INSPEC Data/Cam Sci Abstr, Marine Literature Review, Meteorological and Geoastrophysical Abstracts, Oceanbase, Oceanographic Literature Review, Research Alert, Scisearch. Also covered in the abstract and citation database SCOPUS®. Full text available on ScienceDirect®

Special Section

Mechanisms of sediment retention in estuaries
Gerardo M. E. Perillo and James P. M. Syvitski (Guest Editors)

Research papers

(Contents continued inside)

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Scientific Highlights

Mechanisms of sediment retention in estuaries‡

Gerardo M.E. Perillo[1], James P.M. Syvitski[2]

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‡Excerpt of the present article have been extracted from Perillo and Syvitski (2010) with permission by Elsevier

Estuaries are the primary receiver and retainer ofsediment delivered to the coast by rivers. Their geomorphologic and dynamic characteristics as well as their prevailing biological conditions are essential to define the capability of each estuary to retain sediments within the system. Whether the accommodation space available and the amount of sediment received are enough to permit the evolution of the estuary in phase with long-term sea level trends or anthropogenic modifications requires an in-depth analysis of the unique conditions present.

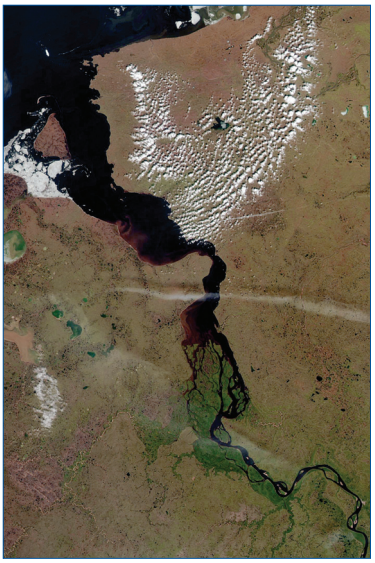

Photo: Yenisey

Estuary in Russia as a MODIS-Aqua image taken July 19 2004, provided by James Syvitski.

Many estuaries are out of equilibrium given 20th century boundary conditions. The sediment load delivered to est uaries has often changed through land use (Syvitski and Milliman, 2007) and from restrictions to offshore sediment sources. Estuaries and wetlands often respond quickly to reductions in sedimentary flux, decreasing their potential to withstand the expected eustatic sea level rise (Nicholls, 2004). Subtidal regions similarly respond to changes in the estuarine sediment budget; a point seldom considered when coastal wetlands are investigated.

Estuaries, including their wetlands, are controlled by hydrodynamic, atmospheric and biogeochemical factors that act upon the original geomorphology by transporting sediment from one place to another (Perillo et al., 2007; Reed et al., 2009, Fig. 1). Over time, cumulative changes grow from the microscale (seldom perceived) to the macroscale (normally perceived by humanity), sometimes passing across some irrecoverable threshold (van de Koppel et al., 2009), inducing a major change in

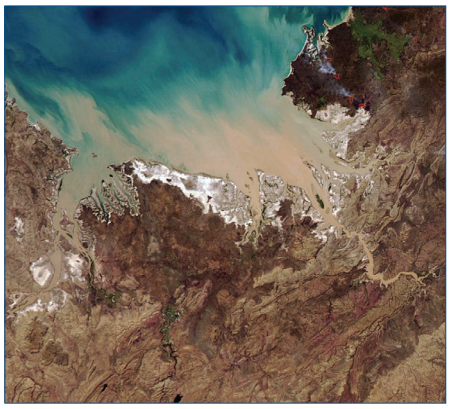

Photo: Australia

MODIS-Aqua image taken June 17 2004, provided by James Syvitski.

The image is the southern portion of the Joseph Bonaparte Gulf showing the Cambridge Gulf to the left and the Queen's Channel to the right.

''state'' of the environment. When this situation becomes noticeable, measures to recuperate the system are very difficult or impossible to implement.

Global climatic changes will affect most coastal environments as they are buffers between the continent and sea. How fast estuaries will respond to changes in 21st century boundary conditions remains a matter of debate. Estuaries exist from the interplay between continental delivery and marine dissipation forces. Ocean energy may carry offshore or littoral sediment into an estuary, as well as disperse material from within the estuary into the coastal ocean. If sediment delivery

Photo: Argentina

Rio de la Plata" estuary in Argentina, a MODIS-Aqua image taken April 3 2002, provided by James Syvitski.

Photo: St. Lawrence
Estuary in Canada a MODIS-Aqua image taken July 21 2002, provided by James Syvitski.

overwhelms dispersal energy, the estuary will accumulate sediment and eventually convert to a delta. Sediment deposits are therefore viewed as a proxy to the health and long-term viability of an estuary.

Pollutants tend to attach to sediment particles and thus follow their fate. Thus to track or predict the behavior of pollutants, one also needs to be able to monitor and model the various sediment retention mechanisms within an estuary.

Estuaries are presently adjusting to changes in mean sea level and to modifications in the water and sediment discharge by rivers and groundwater. The Intergovernmental Panel on Climate Change (IPCC) projects that mean sea level will rise 21–71 cm by 2070, with a best estimate of 44 cm averaged globally (Bindoff et al., 2007) in response to ocean volume expansion. Importantly, many coastal wetlands are subsiding much faster than mean sea level is rising under the influence of human activities (Syvitski et al., 2009), resulting in the inland migration and deepening of the basin which may provide greater accommodation space for sediment trapping.

This is exacerbated by the marked decrease in sediment delivery to the coast due to the construction of dams (Syvistki et al., 2005) and river diversion.

As final output of Working Group 122 under the auspices of the Scientific Committee on Ocean Research (SCOR), the Land-Ocean Interactions in the Coastal Zone (LOICZ), and the International Association for the Physical Sciences of the Oceans (IAPSO), a Special Issue dedicated to the Mechanisms of Sediment Retention in Estuaries has been published by the Estuarine, Coastal and Shelf Science journal (vol. 87, number 2, 2010, Fig. 2). Most of the papers in the issue review the varied sediment trapping mechanism due to the action of currents and waves over tidal flats and marshes, and their interaction with the associated estuary as well. Biological-physical interaction processes play a major role affecting water circulation. However, biology can be either a mechanism to trap and preserve sediment in the estuaries but on the other hand bioturbation put sediment in a position to be readily available for transport. Tidal wetlands are considered one of the primary systems that retain sediments in estuaries; their survival depends entirely on their efficiency in storing the material being supplied but also to develop systems that prevent erosion.

As Co-Chairs of the SCOR-LOICZ working group, we offer this compilation as examples of the diversity of scenarios and to the challenge in our understanding of these endangered coastal environments. The short-term evolution of estuaries deserves our immediate attention. On behalf of all the members of the WG, we thank SCOR, LOICZ and IAPSO for their guidance and support.

Photo: North Sea
MODIS-Aqua image taken March 25 2007, provided by James Syvitski.
The estuaries to the left are the Thames and Essex, UK, and the ones to the right are the Schelde estuaries of The Netherlands.

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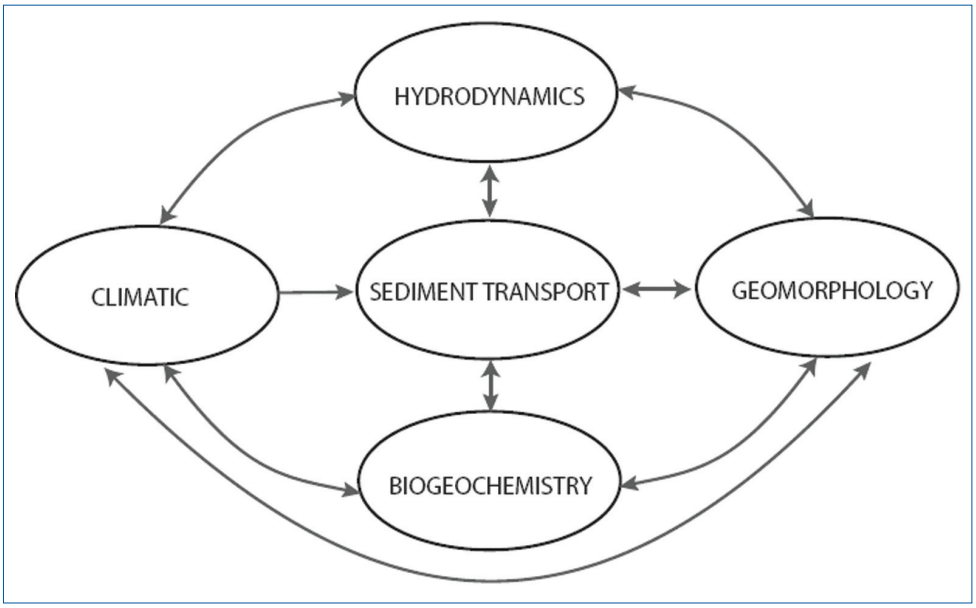

Figure 1: Integrated relations among the different major processes that act upon an estuary (modified from Perillo et al., 2007 and Reed et al., 2009).

Figure 2: Cover of the special issue of Estuarine, Coastal and Shelf Science

read also page 25

2.1.2 WG 126: Role of Viruses in Marine Ecosystems (2004)

Terms of Reference:

- Summarize past results on virus-meditated mortality of algae and prokaryotes and the impact on oceanic carbon and nutrient cycling.
- Coordinate data collection to assess the role of viruses in different water masses.
- Assess the methodological limitations of the techniques available for quantifying the virus-mediated mortality of microorganisms (eukaryotes and prokaryotes) and their impact on carbon and nutrient cycling, and make recommendations for the best available approaches to study viruses and viral processes in the sea.
- Establish and maintain a Web site as forum that can be used by the "viral community" for exchange of data and ideas and future plans.
- Convene an International Symposium that could include a published proceeding such as a special issue of *Limnology and Oceanography* or *Deep-Sea Research*.
- Write a "definitive" textbook on Methods in Marine Virology.

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Manual of Aquatic Viral Ecology (from http://www.aslo.org/books/mave/)

ASLO's first e-Book publication is the **Manual of Aquatic Viral Ecology** (MAVE), edited by Steven Wilhelm, Markus Weinbauer and Curtis Suttle. It contains 19 chapters reflecting state-of-the-art opinions on approaches to studying viruses in aquatic systems. Topics range from the enumeration of viruses to molecular techniques designed to dissect and query individual virus populations as well as communities of viruses. The content of this e-book was selected in consultation with the Scientific Committee for Oceanographic Research's working group on marine viruses, and its publication has been supported by the Gordon and Betty Moore Foundation.

Chapters in the MAVE e-Book are freely available for download. Citations of each chapter should follow the form recommended in its acknowledgments. For the entire book, a suggested citation is as follows.
S.W. Wilhelm, M.G. Weinbauer, and C.A. Suttle [eds.] 2010. *Manual of Aquatic Viral Ecology*. Waco, TX:American Society of Limnology and Oceanography. doi:10.4319/mave.2010.978-0-9845591-0-7

Table of Contents

2-6

2.1.3 WG 128: Natural and Human-Induced Hypoxia and Consequences for Coastal Areas (2005)

Terms of Reference:

- Synthesize the state of the science for the following aspects of coastal hypoxia:
    - prevalence and spatio-temporal variability,
    - natural and human causes,
    - effects on the biogeochemistry and ecology, and
    - resistance, resilience and recovery of ecosystems.
- Identify gaps in our understanding of hypoxia and make recommendations for future research;
- Determine the requirements for observing and modeling hypoxia and its impacts in coastal systems; and
- Document the work of the group in a special issue of a peer-reviewed international journal or a book by a major world publisher.

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Executive Committee Reporter: Peter Burkill

Natural and Human-Induced Hypoxia and Consequences for Coastal Areas: Current Status

Annual Report – 2009/2010

1. Introduction

SCOR WG #128 was officially approved in August 2005. The first meeting of this Working Group was organized at Vienna, Austria on April 6-7, 2006, and coincided with the EGU Annual Assembly. During the Vienna Meeting, members of WG #128 revised the terms of reference of the group, discussed possible activities between the first and second WG meetings, final results to be expected from this Working Group, and the plan for its second meeting in 2007.

The second meeting of WG#128 was held 22-23 September 2007 at Shanghai, China, and coincided with the IMBER/LOICZ Open Science Conference on Continental Margins: "Impacts of Global, Local and Human Forcings on Biogeochemical Cycles and Ecosystems". During the Shanghai meeting, members of WG #128 reported their progress on the preparation of syntheses that are related to the terms of reference of this SCOR Working Group through oral presentations and discussion, and then the preliminary list of synthesis papers was revised.

2. Activities in 2009-2010

Activities of WG #128 were mostly undertaken by e-mail among WG members, long-distance phone calls, and occasional simultaneous participation of several WG members to international conferences (e.g. IMBER-SSC Meeting at Paris in June 2009 and GEOTRACES Arctic Ocean Meeting at Delmonhorst in June 2009).
In order to free up funding for page charges for publication of synthesis papers in a special issue of *Biogeosciences* (see the section below), the third meeting of the group was cancelled.

3. Final results of WG #128

The major activity for this Working Group #128 after its second meeting, in Shanghai, has been to prepare the manuscripts of synthesis papers. The preliminary list of 14 synthesis papers was discussed and revised during the Shanghai meeting. New contributions from WG #128 members were also considered and finally 10 titles were proposed and submitted to the EGU open-access journal *Biogeosciences*, together with the names of lead authors. Scientists from the broader scientific community were also approached and invited to participate in the synthesis work of the group and to contribute as co-authors of synthesis papers led by members of WG #128. It was realized that publication of a special issue in *Biogeosciences* would be far too costly for the WG to fund. We have discussed page charges with the editorial office of *Biogeosciences* and efforts have been made to obtain extra financial support from other sources and from a waiver of service charges. However, these initiatives did not solve the problem of covering the publication costs for 10 papers in total.

The original deadline of submission of synthesis papers for the special issue of *Biogeosciences* was 30 June 2009. But the preparation of manuscripts was delayed for a variety of reasons.
As for the progress of manuscript submission and publication, the latest information (as of June 2010) about the date of completion of synthesis papers is given below.

Eight of the ten synthesis papers have been published in *Biogeosciences,* and can be down loaded on the *Biogeosciences* Web site (http://www.biogeosciences-discuss.net/special_issue33.html):

- Historical record of coastal eutrophication-induced hypoxia (Leading author: Andy Gooday)
- Effects of natural and human-induced hypoxia on coastal benthos (Leading author: Lisa Levin)
- Coastal hypoxia and sediment biogeochemistry (Leading author: Jack Middelburg)
- Impacts of hypoxia on the structure and processes in the pelagic community (zooplankton, macro-invertebrates and fish) (Leading author: Werner Ekau)
- Coastal hypoxia responses to remediation (Leading author: Mike Kemp)
- Modeling of dissolved oxygen dynamics and coastal hypoxia: A review (Leading author: Angelica Peña)
- Dynamics and distribution of natural and human-induced coastal hypoxia (Leading author: Nancy Rabalais)
- Natural and human-induced hypoxia and consequences for coastal areas: Synthesis and future development (Leading author: Jing Zhang)

As of June 2010, two other synthesis papers are in revision and preparation for the final versions, including:

- Evidence for greater oxygen decline rates in the coastal ocean than in the open ocean (Leading author: Denis Gilbert)
- Coastal hypoxia/anoxia as a source of CH_4 and N_2O (Leading author: Wajih Naqvi)

4. Web site of WG #128

A Web site (http://kopc01.gkss.de:8080/LOICZWG128Wiki/Wiki.jsp) for SCOR WG #128 was created with the help of the LOICZ IPO through Nancy Rabalais, LOICZ SSC Vice-chair, to help establish the cross-link between the two organizations since 2007. The idea was to have a joint facility for sharing the references of WG #128 and to have a password-enabled Web-site that WG members could use for circulation of manuscripts and open discussion on WG-related activities. With help from the LOICZ IPO, information of this Working Group is cross-linked with the LOICZ Web site, which is highly appreciated by this WG. This is considered to be an active, dynamic link between SCOR WG #128 and LOICZ. With ID and passwords provided by LOICZ, every WG member can upload their synthesis manuscripts and/or check with papers led by other WG members. We take this opportunity to acknowledge once again the support that LOICZ has provided in establishing and maintaining this Web site.

5. Other activities of WG#128

Contribution to other international conferences and organizations by this SCOR WG #128 include

- GEOTRACES Arctic Ocean Planning Workshop at Delmenhorst, Germany (Jing Zhang) in 8-10 July 2009
- Primer Congresso Oceanografia Fisica Meteorologica y Clima in Concepcion, Chile (Boris Dewitte) in 30 Sep - 2 Oct, 2009

- Ecological Society of America, Invited, Special Session on Coupled Biogeochemical Cycles. Albuquerque, August 2009 (N Rabalais)
- UNEP/STAP workshop on linkages between eutrophication and hypoxia, Shanghai, China, 21-24 October 2009 (M. Kemp, T. Oguz, W. Naqvi, J. Zhang, Díaz, R.J. and N.N. Rabalais)
- HYPOX kick-off meeting at Max Planck Institute for Marine Microbiology, 15-17 May 2009 (Jack Middelburg)

6. Links with other international programs

Communication of our activities to other scientific groups should be maintained to help move forward the study of coastal hypoxia and to establish partnerships with SCOR WG#128:

IMBER (Jing Zhang, Jack Middelburg, Wajih Naqvi)	GEOHAB (Pedro Monteiro)
LOICZ (Nancy Rabalais)	SCOPE (Venu Ittekkot)
GLOBEC (Werner Ekau, Anja van der Plas)	Argo (Denis Gilbert, Osvaldo Ulloa)
SOLAS (Osvaldo Ulloa)	IOC/WESTPAC (Jing Zhang)
Census of Marine Life - COMARGE/CHESS (Lisa Levin)	

7. Completion of the Working Group Activities

The major task at this time is to complete the special issue of "Coastal Hypoxia" in *Biogeosciences*, as this is the key final product of this Working Group.

As approved by SCOR on its annual meeting in 2008, there will be no third meeting of this WG #128, the budget having been used to cover the publication cost (i.e. page charge) of the *Biogeosciences* Special Issue on "Coastal Hypoxia".

2.2 Current Working Groups

2.2.1 WG 111: Coupling of Winds, Waves and Currents in Coastal Models (1996)

Terms of Reference:

- To review the present status of our knowledge on each component of coastal dynamics: coastal wave models, coastal circulation models, and the coastal atmospheric boundary layer models.
- To examine the existing coastal circulation and wave data from both conventional and remotely sensed sources to detect possible weaknesses of uncoupled models, and to address the issues of a coupled model.
- To build and strengthen a collaborative research effort on a coupled coastal dynamics model, between wave, circulation and coastal meteorology modelers, both among the members of the Working Group and with other existing groups.
- To estimate the contribution of coastal waters in heat exchange between the atmosphere and the ocean, which has importance for global modeling and climate studies.
- To prepare a final report summarizing the present status of our knowledge, recommending future research and observational studies of the coastal regions.

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Michael Banner	AUSTRALIA	Eloi Melo	BRAZIL
Jurjen Battjes	NETHERLANDS	Yoshiaki Toba	JAPAN
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Executive Committee Reporter: Lawrence Mysak

2.2.2 WG 124: Analyzing the Links Between Present Oceanic Processes and Paleo-Records (LINKS) (with IMAGES) (2003)

Terms of Reference:

- Use the new insights gained from contemporary ocean biogeochemical studies to identify or refine our understanding of key oceanic processes and develop or improve proxies for these processes for subsequent use in paleoceanographic studies.
- Refine established proxies, provide mechanistic understanding and foster the development of new proxies within integrated multidisciplinary process studies in the modern ocean.
- Use proxy evidence from the sedimentary records to test hypotheses of the oceanic response to climate change.

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2.2.3 WG 125: Global Comparisons of Zooplankton Time Series (2004)

Terms of Reference:

- Identify and consolidate a globally representative set of "long zooplankton time series" (selected from the data sets listed in Table 1, plus perhaps from additional regions for which time series can be pieced together from a sequence of shorter programs).
- Facilitate migration of individual data sets to a permanent and secure electronic archive.
- Develop and share protocols for within-region and within-time period data summarization (e.g., spatial, seasonal and annual averaging, summation within taxonomic and age categories).
- Based on the above, develop priorities and recommendations for future monitoring efforts and for more detailed re-analysis of existing sample archives.
- Carry out a global comparison of zooplankton time series using (in parallel) a diverse suite of numerical methods, examining

  1. Synchronies in timing of major fluctuations, of whatever form.
  2. Correlation structure (scale and spatial pattern) for particular modes of zooplankton variability (e.g., changes in total biomass, replacement of crustacean by gelatinous taxa, alongshore or cross-shore displacements of zoogeographic distribution boundaries).
  3. Amplitude of variability, both for total biomass and for individual taxa, and comparison to the amplitude of population fluctuations of predator species (fishes, seabirds, marine mammals). Is there amplification at higher levels of the food web?
  4. Likely causal mechanisms and consequences for the zooplankton variability, based on spatial and temporal coherence with environmental and fishery time series.
  5. Sensitivity and specificity of data-analysis tools.

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Update on SCOR WG125 "Global Comparison of Zooplankton Time Series"

SCOR WG125 held its final working group meeting on May 15-16 2008 in Gijón Spain, hosted by the Gijón laboratory of the Instituto Español de Oceanografía. The two day meeting was attended by most of the WG Members and Associate Members, plus by several IEO staff. The main purpose of this meeting was hands-on data analysis by various teams of investigators, and deciding how these analyses will ultimately be presented and published.

Preliminary versions of many of the comparative analyses were presented the following week in the International Symposium 'Effects of Climate Change on the World's Oceans' (sponsors IOC, ICES, PICES, SCOR, GLOBEC, and WCRP). These and others have subsequently been submitted to *Progress in Oceanography* for a planned special issue on zooplankton time series, guest edited by Pierre Pepin, Mackas, and Verheye. Although progress has been slow, the majority of papers are now in their second round of revision. We expect to be completed by the autumn 2010

The WG125 goal of global comparison received very good 'buy-in' by the international community of marine zooplanktologists. We had access to over 100 zooplankton time series, from over 25 countries. One consequence was a need for a suite of 'entry-level' data analysis and visualization tools that could be applied across diverse sampling designs (frequent sampling of a single site vs. seasonally-repeated survey grids vs. irregular repeat averages within defined statistical areas); sampling methods (horizontal, vertical or oblique net tows; different net designs and mesh sizes); and measurement currencies (displacement volume, dry-weight biomass, carbon biomass, numeric abundance at varying levels of taxonomic aggregation). Our approach (implemented mostly by Todd OBrien; illustrated in Fig. 1) has been to estimate average seasonal cycles from log-transformed raw time series, then use these baselines to calculate anomaly time series, and finally to display both data and anomalies as color-coded pixel grids that show which seasons/years have unusually high or low values. These simple graphical displays have been useful not only for comparison among time series, but also for within-time-series quality control and hypothesis building.

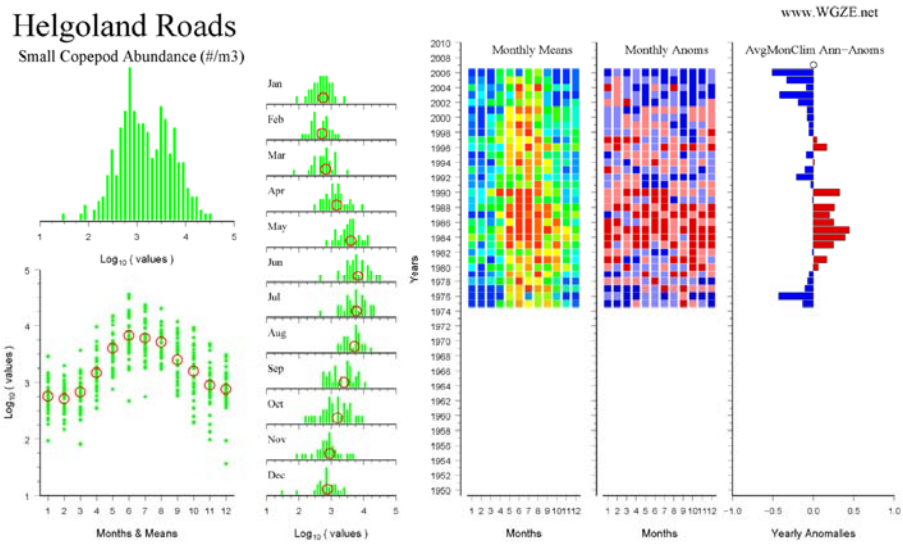

Fig 1. Graphical output from the WG125 toolkit, applied to W. Greve's 'long and dense' Helgoland Roads time series. The green dots and bars in the three left-side panels show overall and within-month frequency-distributions of individual data points. Red circles overlaid on the bottom-left graph show the average seasonal cycle. Color-coded pixels in the middle panel show ranking of within-month means. The right hand panels show monthly and annual-average anomalies.

Nearly all of our available zooplankton time series provide one or more indices of 'total amount': biovolume, biomass, or total abundance. One of our main comparisons was of how the amplitudes of fluctuations and trends differ among regions. To address this, we ranked time series based on the max-to-min

or RMS 'span' of their anomaly time series (Fig. 2 ranking map, from OBrien et al. presentation and manuscript). The strongest interannual variability was in the zooplankton time series from sub-polar regions, from the eastern boundary current upwelling systems, and from the ocean margins off Korea and Japan. Conversely, the smallest range of variation was found in the time series from mid-latitude continental shelf regions and from the European marginal seas.

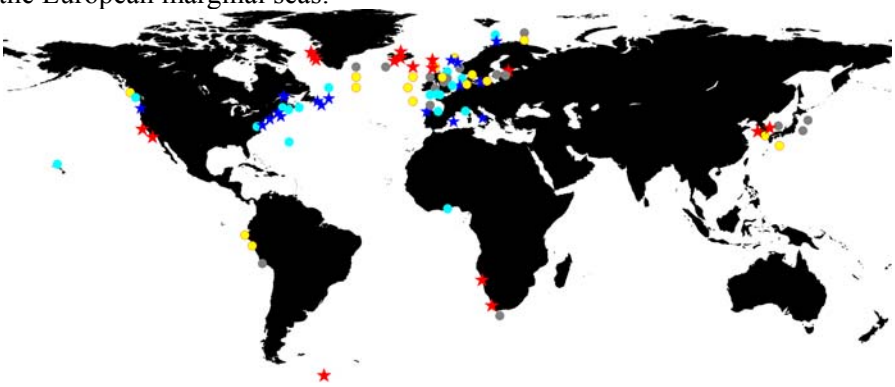

Fig. 2. Map of 'anomaly span'. Red and yellow symbols show locations of time series with a large interannual range, blue symbols have a much smaller range (some because they are brief). Grey symbols are intermediate.

Another important comparison is of which time series are most 'synchronous', and how their degree of temporal correlation varies with spatial separation. Hal Batchelder has done a spatial autocorrelation analysis (Fig 3) of the 'biomass' time series. He found that the biomass time series are positively but relatively weakly correlated across separations smaller than a few thousand kilometers, that the spatial autocorrelation is stronger in the Pacific than in the Atlantic, but that there is no evidence supporting the 'global synchrony' suggested by catch time series of anchovy and sardines. Does this mean that fish 'regimes' are more teleconnected than zooplankton 'regimes'? Perhaps, but not necessarily – the zooplankton analysis is of a highly aggregated currency (total biomass), while the fish analyses are at species level. Comparisons within the California Current system show that the short-range spatial autocorrelation of zooplankton community variability is considerably stronger than the spatial autocorrelation of total zooplankton amount (Fig 3).

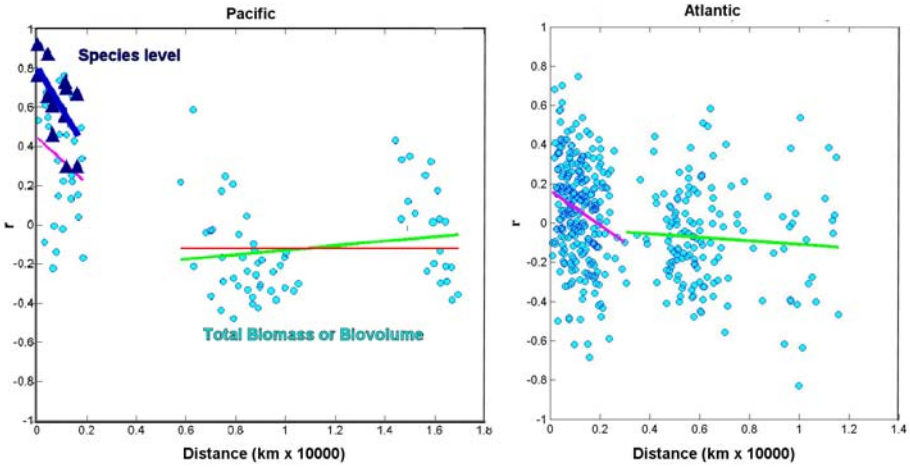

Fig 3. Spatial correlograms for zooplankton anomaly time series from the Pacific (left, total biomass and community composition) and Atlantic (right, total biomass only). In both oceans, correlation decays to zero at separations greater than a few thousand km (i.e .there is little or no global synchrony). However, 'local' synchrony stronger in the Pacific than in the Atlantic, and are much stronger at species level than for total biomass. From Batchelder et al. and Mackas et al. presentations.

2.2.4 SCOR/IAPSO WG 127: Thermodynamics and Equation of State of Seawater (2005)

Terms of Reference:

- To examine the results of recent research in ocean thermodynamics with a view to recommending a change to the internationally recommended algorithms for evaluating density and related quantities (including enthalpy, entropy and potential temperature). Such recommendations would take into account the reformulation of the International Temperature Scale (ITS-90).
- To examine the most accurate recent knowledge of the freezing temperature of seawater, the calculation of dissolved oxygen, and the behaviour of seawater at high salinity.
- To examine the feasibility of using simple functions of three-dimensional space to take account of the spatially varying concentrations of alkalinity, total carbon dioxide, calcium and silica place on the determination of density in the ocean.
- To extend these concepts to a wider range of physical/chemical issues of relevance to the internal working of the ocean and of its interaction with the atmosphere and to present and potential future observational techniques.
- To write a set of related recommendations on the above topics in the form of a report to SCOR/IAPSO and a review or series of reviews to be published in the scientific literature.

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Petra Spitzer	GERMANY
Dan Wright	CANADA

Associate Member:

Rich Pawlowicz	CANADA
Steffen Seitz	GERMANY
Peter Tremaine	CANADA

Executive Committee Reporter: Lawrence Mysak

Progress Report to SCOR, June 2010 on
SCOR/IAPSO Working Group 127 on the
Thermodynamics and Equation of State of Seawater

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Rainer Feistel (Germany)
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Giles M. Marion (USA)
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Dan Wright (Canada)

Associate Members
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Rich Pawlowicz (Canada)

1. Working Group Meetings

SCOR/IAPSO WG127 was approved in 2005, had its first meeting at Warnemünde in May 2006, and its second meeting at Reggio, Italy in May 2007. The third meeting was in Berlin from 3-9 September 2008. The fourth and final meeting of the Working Group took place 2-5 September 2009 in Arnhem, the Netherlands. This meeting was attended by all full members apart from Dr David Jackett (due to ill health) and by all Associate Members except Dr Peter Tremaine. We also had the managing director of Seabird instruments at this meeting. Partial financial support for this fourth meeting came from a grant of US$8,000 from the USA.

2. Requests to SCOR concerning membership or terms of reference

There are no requests for changes in membership or terms of reference.

3. Activities between working group meetings

Many of the issues on our agenda are being pursued by individual members, and by subcommittees of WG127.

4. Next Working Group Meeting

No further meetings of the Working Group are planned.

5. Assessment of Progress

(1) In June 2009 IOC, at its 25th Assembly, adopted Resolution XXV-7, namely

> **"…Decides** to adopt the International Thermodynamic Equation of Seawater (TEOS-10) formulation that has been developed and recommended by the SCOR/IAPSO WG-127 to replace the existing EOS-80, as presented in the TEOS-10 Manual,…"

(2) The TEOS-10 Manual has now been published (in English) as

> IOC, SCOR and IAPSO, 2010: *The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties*. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 196 pp. Available from IOC, and electronically from http://www.TEOS-10.org

(This TEOS-10 Manual is attached, as a pdf, to this email progress report of WG127. It is now available in hard copy from IOC.)

(3) WG127 and IOC have now begun to write a succinct summary of the TEOS-10 Manual in the form of a User's Guide. This User's Guide will be translated into several languages, and will be referenced as

> IOC, SCOR and IAPSO, 2010: *User's guide to the international thermodynamic equation of seawater–2010*. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56 (abridged edition), UNESCO, ~30pp.

(4) In a few weeks I expect that IOC, SCOR and IAPSO will write to the editors of about twenty oceanographic journals, asking them to publish a notice about the adoption of TEOS-10 to replace EOS-80. The draft notice and draft list of editors is attached to this progress report. This draft has been cleared through SCOR and IAPSO, and it is now in IOC's hands for action.

(5) WG127 has created and is maintaining the web site http://www.TEOS-10.org which serves many of the TEOS-10 papers and the TEOS-10 Manual as well as key software.

(6) To support users in adopting TEOS-10, WG127 has developed an extensive source-code library referred to as the Sea-Ice-Air (SIA) library, to be published in *Ocean Science* under the Creative Commons Attribution 3.0 License for free access.

(7) In September 2009 IAPWS (the International Association for the Properties of Water and Steam) adopted the pure water part of the Feistel (2003) Gibbs function as an official IAPWS Release. In the oceanographic ranges of temperature and pressure, this pure-water Gibbs function is a factor of 65 times computationally faster than using the IAPWS-95 Helmholtz function for this purpose. The GSW software served from http://www.TEOS-10.org uses this faster approach. With this Release, IAPWS has now examined and approved the TEOS-10 Gibbs functions for freshwater, for seawater and for ice. It is expected that the TEOS-10 Gibbs function for sea air (moist air in contact with seawater) will also be adopted as an IAPWS Release in September 2010, at the annual IAPWS meeting at Niagara Falls, Canada. This will complete a series of four Gibbs functions, all constructed by Rainer Feistel (pure water IAPWS-

09, seawater IAPWS-08, ice IAPWS-06, and sea-air IAPWS-10), which will have been issued as Releases and a Guideline of IAPWS and which form the backbone of TEOS-10 for oceanographers.

(8) In September 2009 IAPWS established its Subcommittee on Seawater, to which WG127 members are contributing their oceanographic expertise; IAPWS has direct interest in the properties of seawater because of the use of seawater in cooling towers of power stations and in desalination plants.

(9) During the past year the individual members of WG127 have continued to publish many papers which underlie TEOS-10. Several of these papers have appeared as open access in *Ocean Science*, while some are still under review at this journal, http://www.ocean-sci-discuss.net/special_issue23.html . These *Ocean Science* papers will be drawn together into a special issue of that journal. See Appendix C of the TEOS-10 Manual, and particularly pages 131-132 for an indication of the publishing activity in which members of WG127 are engaged.

(10) TEOS-10 was presented and well received at leading international metrological conferences such as the WMO/BIPM Meeting 2010 in Geneva, Switzerland (http://www.bipm.org/en/events/wmo-bipm_workshop/), and the TEMPMEKO/ISHM Symposium 2010 in Portoroz, Slovenia (http://www.tempmeko-ishm.org/). Key issues were the high accuracy, extended range of validity and rigorous consistency of the TEOS-10 equations for geophysical substances not only for seawater, and the new approach of WG127 to establish for the first time metrological traceability to the SI of salinity measurements, in order to foster the comparability of climatological ocean observations on a century timescale. The importance of metrological measurement principles for reliable assessments of the changing climate was emphasized by WMO signing in 2010 the Mutual Recognition Agreement (MRA) of BIPM. WG127 in cooperation with National Metrological Institutes such as the PTB Germany is working towards a mutually recognised metrological foundation for TEOS-10.

6. Next Steps

The imminent publication of a one-page announcement about TEOS-10 in the many oceanographic journals will probably be the "go button" for many university-based principal investigators. Already we are encouraged to see a paper that is "in press", by an oceanographer who is not a WG127 member, that uses TEOS-10 and Absolute Salinity.

In order to expedite the adoption of TEOS-10 by the oceanographic community it has become clear that

(i) the code distributed by equipment manufacturers such as Seabird needs to migrate from EOS-80 to TEOS-10, and
(ii) forward ocean model codes such as MOM4 (GFDL, Princeton) and NEMO (European, based in Paris) adopt TEOS-10.

WG127 is in discussion with Seabird and with code-developers of the MOM4 and NEMO models, and some progress has been made. For example, Seabird is committed to making the transition to TEOS-10 and we are continuing a dialogue to assist this. Also, Conservative

Temperature has now been incorporated into MOM4 (but not Absolute Salinity as yet), and we have some offers in hand to make the necessary changes to NEMO.

WG127 will continue this year to achieve (i) and (ii) above, as well as to complete the publication of the final few manuscripts that we have on our plate.

Last year in the WG127 report we recommended that WG127 continue as a SCOR/IAPSO Working Group until "31 December 2010 so as to be a source of advice regarding the introduction of this new standard". It is likely that the need for this advice will continue beyond the end of 2010, but at this time it is not totally clear to us what the best form of a continuing group would be. At this stage it seems best to request that WG127 continue to exist as a fully fledged Working Group until mid-2011. Because IAPWS has a continuing interest in the properties of seawater, and because IAPWS has now established a subcommittee on Seawater with Rainer Feistel as its chair, one possibility is that during 2011 we merge this IAPWS subcommittee with SCOR/IAPSO WG127 with a consolidated membership. If this suggestion was agreeable to SCOR and IAPSO, then Rainer Feistel and myself could work on this idea over the coming year.

Trevor J McDougall
Chair, SCOR/IAPSO Working Group 127

TEOS-10

- The existing 1980 International Equation of State for seawater was published by UNESCO
- SCOR/IAPSO Working Group 127 was formed to update this standard and worked from 2005-2008 to do so.
- The TEOS-10 standard was distributed to IOC member states for comment by circular letter, and further considered by relevant subsidiary bodies, including GOOS, IODE and GSSC, in early 2009
- The working group presented its new, TEOS-10 formulation to the 25th IOC Assembly in June 2009
- The Assembly adopted the TEOS-10 by resolution XXV-7.
- The IOC sponsored a final "extra" meeting of Working Group 127 in 2009.
- The TEOS-10 Manual is in press in the *IOC Manuals and Guides* series, as a joint IOC/SCOR/IAPSO publication
- A short and simplified 'users guide' is in preparation for publication in the same series, and for broad distribution in multiple languages.
- IOC will continue to work with SCOR and IAPSO and other partners to ensure TEOS-10 is disseminated broadly to government agencies, the scientific community, and industry.

2.2.5 WG 129: Deep Ocean Exchanges with the Shelf (with IAPSO) (2006)

Terms of Reference:

1. Establish the current state of knowledge and make recommendations for future research related to the following topics:
   - Processes due to shelf waves, internal tides, shelf break upwelling, storms and extreme events that produce effects over time scales of weeks to one or two years;
   - Transport over the shelf and shelf break of riverine and estuarine input of sediment and fresh water (this aspect includes the Arctic and Antarctic coastal zones, but does not include investigating the sources of sediment and fresh water on the shelves);
   - Dissipation of tidal motion along the continental margins on time scales of hours to days;
   - The physical controls of chemical and biological fluxes between the shelf and the open ocean that can affect the ecology of such regions; and
   - Coupled physical-chemical-biological models, generally at local to regional scales, that have a more realistic description of the exchanges at the shelf edge;
2. Determine where further observational programmes (using improved technology) are needed to improve understanding of shelf break processes and to provide help with the formulation of more realistic models of the fluxes between the shelf and the deep ocean;
3. Serve as an international forum for oceanographers to discuss current research on the interaction between the coastal zone and the deep ocean, by using the services and membership data base provided by IAPSO;
4. Foster collaboration between developed and developing countries that have interest in the shelf zone; limited-area models are required to help scientists in countries that do not have access to large computers, and
5. Produce a comprehensive, published final report incorporating the latest results on the above topics. This report will be in a form of a special issue of a peer-reviewed journal or a book by a major publisher.

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SCOR/IAPSO WG 129 Deep Ocean Exchange with the Shelf

4th Annual Report - 9th June 2010

1. Eugene LaFond Medal

The IAPSO Eugene LaFond Medal was awarded to Bamow Sow for his talk at the DOES Symposium at MOCA-09 In Montreal in July 2009. The title of his talk was "Simulation of the Senegalese and Mauritanian upwelling: How are the winds actually driving SST variability and water mass renewal". The medal is given for a talk by a delegate from a developing country.

Bamow Sow attended the SCOR/IAPSO Cape Town DOES workshop and was an observer for one day at the WG 129 meeting in Montreal. He received financial support from SCOR and IAPSO to attend these meetings, and was part of the SCOR/IAPSO outreach programmes.

2. Terms of Reference

2.1 *Synthesize the state of DOES science and make recommendations for future research.*
A bibliography has been produced containing over 700 references and the data for a shelf atlas is being compiled. To make these products useful for the future, some computing expertise is required and discussions have been held with Ed Urban about this. We concluded that the appropriate actions would be to (1) identify an appropriate reference database in which to store the references; and (3) make the database available through the SCOR Web site.
Recommendations for future research on DOES have been collected from members and associates of the WG. A summary of these recommendations will be included in John Johnson's introduction to the DOES special issue of *Ocean Science*.
2.2 *Determine where further observational programmes (using improved technology) are needed to improve understanding of shelf break processes and to provide help with the formulation of more realistic models of the fluxes between the shelf and the deep ocean.*
See Cape Town meeting report, particularly Working Group 6 for observational programmes and Working Group 5 for future modeling. A summary of these recommendations will also be included in the introduction to the DOES special issue of *Ocean Science*.
2.3 *Serve as an international forum for oceanographers to discuss current research on the interaction between the coastal zone and the deep ocean, by using the services and membership database provided by IAPSO.*
The international forum for DOES research was begun by WG 129 setting up the successful international workshop in Cape Town in 2008. This forum continued with the symposium organized by John Johnson and Piers Chapman at the IAPSO MOCA09 meeting in Montreal in

2009. This forum will continue in a symposium organized by Alberto Piola and Ricardo Matano (both DOES associates) later in 2010 at the AGU Meeting of the Americas.

2.4 *Foster collaboration between developed and developing countries that have interest in the shelf zone; limited-area models are required to help scientists in countries that do not have access to large computers.*

To foster serious collaboration between scientists in developing countries and developed countries requires a significant amount of money, which WG 129 did not have. However, we encouraged students from various maritime countries in Africa to attend the Cape Town Workshop with support as part of the outreach programmes of SCOR and IUGG.

A new initiative by Christine Provost (another associate of DOES) is the plan for a future EU initial training network on DOES topics to bring research students from developing countries to participate in EU workshops.

2.5 *Produce a comprehensive, published final report incorporating the latest results on the above topics. This report will be in a form of a special issue of a peer-reviewed journal or a book by a major publisher.*
The final published work from WG 129 will be the special DOES issue of *Ocean Science*, which is due to appear later in 2010. This will include the selection of papers listed in section 3 of this report plus the recommendations of WG 129 in the Introduction to the special issue.

3. DOES special issue

The special issue of the *Ocean Science* journal on Deep Ocean Exchange with the Shelf is almost complete. *Ocean Science* is an open-access peer-reviewed journal published by the European Geosciences Union. It is expected that the bound volume of the DOES special issue will be available later in 2010. The following nine papers are already published in *Ocean Science*:

- The Kuroshio exchange with the South and East China Seas by T. Matsuno, J.-S. Lee, and S. Yanao, *Ocean Science*, **5**, 303-312, 2009
- A review of the role of submarine canyons in deep-ocean exchange with the shelf by S. E. Allen and X. Durrieu de Madron, *Ocean Science***,** **5**, 607-620, 2009
- Deep ocean exchange with west-European shelf seas by J. M. Huthnance, J. T. Holt, and S. L. Wakelin, *Ocean Science*, **5**, 621-634, 2009
- Carbon export and sequestration in the southern Benguela upwelling system: lower and upper estimates by H. N. Waldron, P. M. S. Monteiro, and N. C. Swart, *Ocean Science*, **5**, 711-718, 2009
- Transformation of an Agulhas eddy near the continental slope by S. Baker-Yeboah, G.

Flierl, G. Sutyrin, and Y. Zhang, *Ocean Science*, **6**, 143-159, 2010

- Surface expression of Mediterranean Water dipoles and their contribution to the shelf/slope–open ocean exchange by N. Serra, I. Ambar, and D. Boutov, *Ocean Science*, **6**, 191-209, 2010
- Malvinas-slope water intrusions on the northern Patagonia continental shelf by A. Piola, N. Martínez Avellaneda, R. Guerrero, F. Jardón, E. Palma, and S.Romero, *Ocean Science*, **6**, 345-359, 2010
- Exchange across the shelf break at high southern latitudes by J. M. Klinck and M. S. Dinniman, *Ocean Science*, **6**, 513-524, 2010
- The role of continental shelves in nitrogen and carbon cycling: Northwestern North Atlantic case study by K. Fennel, *Ocean Science*, **6**, 539-548, 2010

The following two papers are under open review for *Ocean Science*:

- The influence of the Brazil and Malvinas Currents on the SW Atlantic shelf circulation by R. Matano, E. Palma, and A. Piola
- Influences of cross-shelf water transport on the nutrients and phytoplankton in the East China Sea: a model study by L. Zhao and X. Guo

Two papers are awaited:

- Ocean chemistry in the Gulf of Mexico and along the eastern US coast by P. Chapman
- The Introduction to the special issue and the recommendations from WG 129 by J. Johnson

4. World Ocean Shelf Group

In the 3rd annual report of WG 129, the proposal coming out of the Cape Town workshop for a World Ocean Shelf Group and a Global Cross Shelf Exchange Experiment was mentioned. Further discussions at the WG meeting in Montreal in 2009 led to the view that an umbrella group under the auspices of SCOR or IAPSO or IOC was needed to facilitate bilateral and multilateral collaboration between national research groups and particularly to bring in groups from developing countries. Such collaboration already exists around Australia, around Antarctica, in the East China Sea and off West Africa.

This proposal originated from younger scientists at the Cape Town workshop. Younger scientists who have shown an interest in being part of such an umbrella group are Ricardo Matano (USA), DongLianag Yuan (China), Xavier de Madron (France), Jonathon Sharples (UK), Anna Wåhlin (Sweden), Bamow Sow (Senegal) and Mauro Cirano (Brazil). Matano and Yuan would be good leaders.

The main goal of the observational programme in a Global Cross Shelf Exchange Experiment would be improving estimates of fluxes transferred across the deep ocean shelf interface. As the flux depends on the mechanism involved, which depends in turn on local dynamics, these will determine the design of the observational arrays.

An example of the sort of collaboration required is the Integrated Marine Observing System for Australia (IMOS) that has been set up to assemble and provide free, open and timely access to streams of data that support research at the various oceanographic laboratories around Australia. John Middleton, a member of WG 129, is one of the leaders of this group and will be convening an IAPSO symposium at the IUGG meeting in Melbourne 2011 on "New insights from sustained ocean observing systems".

5. Talks on DOES

John Johnson (co-chair, WG 129) gave a talk about DOES at the Norwegian Academy of Science and Letters, Oslo in 2009 and a seminar on DOES at the University of Delaware, Newark, DE in 2010.

2.2.6 WG 130: Automatic Visual Plankton Identification
(2006)

Terms of Reference:

- To encourage the international co-operation of software developers and marine scientists to use and enhance an appropriate open-source development platform, so that a common toolset can be built up over time that is of value to the community
- To evaluate the limits of taxonomic resolution possible from image-based classifiers and develop means of improving the taxonomic resolution that can be achieved from plankton images. The working group will establish a basis for standards in taxonomic reporting by automatic labelling instruments.
- To review existing practices and establish standards in the use of reference image data used for training automation machines and in training people.
- To establish a methodology for inter-comparison/calibration of different visual analysis systems.
- To develop open-source software for application by the marine ecology, taxonomy and systems developers. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognised, peer-reviewed journal or a book by a major publisher

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SCOR Working Group 130: Automatic Visual Plankton Identification

2010 Annual Report

SCOR WG130 at Laboratoire d'Océanographie de Villefranche [Photo: Hans Verheye]

Summary

This report summarizes the activities of SCOR Working Group 130 over the past year culminating with our annual meeting held in Villefranche, France 25th-27th May 2010. SCOR Working Group 130 was initiated in 2007 to address research issues associated with automated approaches for identifying and classifying plankton from image datasets. There is an increased demand on the marine plankton research community, as monitoring global environmental change requires more detailed ecological data, and as environmental disasters (typified by the Gulf of Mexico oil spill in May 2010) require urgent impact assessments on damaged marine biological

communities.

Since our last report, there has been an increase in the use of semi-automatic methods for plankton identification, for example Zooscan and Flowcam instruments that are coupled to automatic image analysis and specimen identification software. This in turn is allowing rapid plankton sample analysis with results being published and uploaded to Pangaea, for example, within hours of the sample arriving at the laboratory.

In addition several studies have been completed by members of SCOR WG130 that explore issues of instrument inter-calibration, the exchange of data between users of different automatic analysis toolsets, and the potential use of non-linear matched-filters for species-specific identifications in the field. It is anticipated that these will be published in due course.

Work continues on the further study of Ocean Weather Station India sample set from 1975 (source: R Williams, PML), where inter-calibration issues between Zooscan instruments and also between humans is being investigated.

A series of disseminations are taking place that advertise the outputs of WG130 to the wider community, including a special session at the ASLO Summer 2010 conference at Santa Fe (June 2010), a one-day workshop at the Zooplankton Productivity Symposium (ZPS) meeting in Pucon, Chile in March 2011, and a special issue of the *Journal of Plankton Research* on the topic of automatic visual plankton identification is being discussed with the editor. Our final meeting will be held at the ZPS venue. This will not require funding by SCOR.

Background

SCOR WG130 was initiated in 2007 to address research issues associated with automated approaches for identifying and classifying plankton from image datasets. Our first meeting was held in Hiroshima, Japan in 2007 following the 4th Annual Zooplankton Production Symposium. The second meeting of the working group was held near the town of Ubatuba at the Hotel Recanto das Toninhas on May 7 – 9, 2008. Funding for the second meeting was facilitated by a generous grant from the Brazilian petroleum company Petrobras to working group member Rubens Lopes. The third meeting of our working group was held in Baton Rouge, Louisiana at Louisiana State University in May 2009 with support from SCOR and an NSF grant to Mark Benfield. The fourth meeting, hosted by Gaby Gorsky, was held at the CNRS Laboratoire d'Océanographie de Villefranche (LOV), in Villefranche-sur-Mer, France on May 26-27th 2010.

As a scientific community and a SCOR working group we must be aware of the current status of automatic imaging and automated recognition of marine plankton. We need to emphasize to the taxonomic/biodiversity community that, given the present state of development of machine vision technology, we are not attempting to develop imaging systems to address their problem of detailed taxonomic identification (i.e. to species level) of plankton in the oceans. Rather, we are going to provide more effective tools for the ecological marine research community. This is probably best achieved through conference presentations and journal papers, but it is becoming clearer to us all that SCOR, or other appropriate body, must embark on a widespread training programme for marine ecology PhD students and laboratory support technicians in the benefits

of computer-based visual identification of plankton and how to use and maintain such systems in their laboratories.

The currently available commercial imaging systems, such as FlowCAM, Zooscan, the Video Plankton Recorder (VPR), and the open-source Zoo/PhytoImage-scanner combination, are adequate for many marine scientists working on ecological research. There is no need to dramatically improve the image quality and resolution to the point that we might attempt to recognize morphologically similar species or classify organisms to fine levels such as the developmental stages of Crustacea. Taxonomic resolution to genus/family and even order may contain sufficient information to satisfy the research criteria of many ecological programmes. In some cases, where species diversity is low and species of interest possess distinctive morphologies, species-level classifications may be feasible.

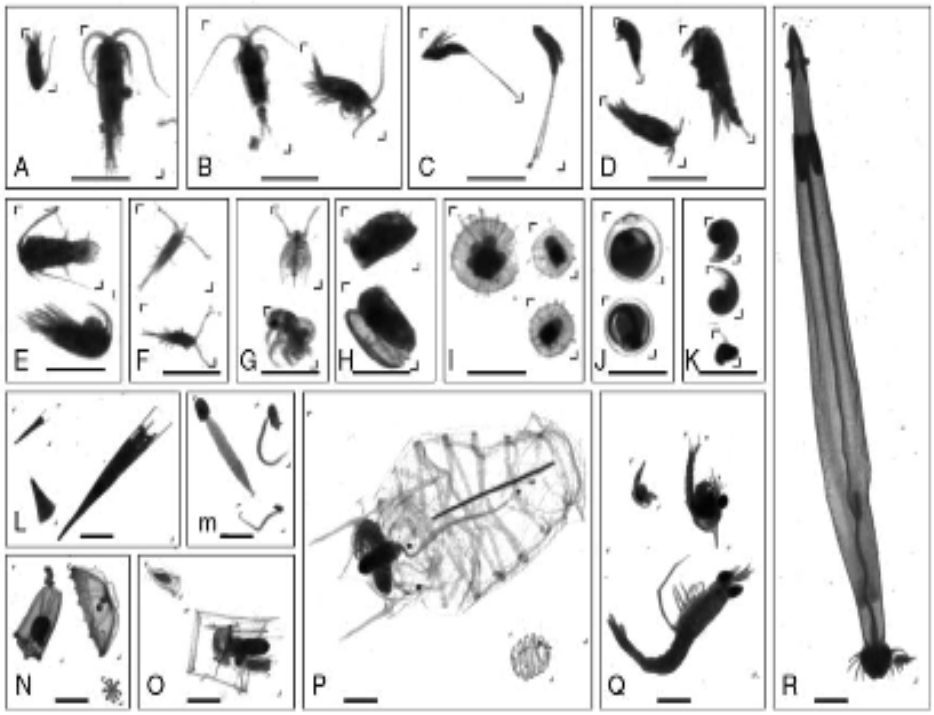

Figure 1: Examples of vignettes of organisms from ZooScan analysis of the 2007–2008 time series in the Bay of Villefranche-sur-mer (scale bar 1⁄4 1 mm). (A) Copepods, (B) Centropages, (C) Harpacticoida, (D) Poecilostomatoida, (E) Temora, (F) Oithona, (G) Cladocera, (H) Ostracoda, (I) Radiolaria, (J) eggs, (K) Limacina, (L) Pteropoda, (M) Appendicularia, (N) medusae, (O) Siphonophora, (P) Thaliacea, (Q) Decapoda, (R) Chaetognatha. (from Figure 8 Gorsky et al. 2010)

Current and new imaging systems afford researchers practical tools that permit acquisition of samples with high spatial and temporal resolution. When coupled to automatic identification

software these instruments greatly increase the numbers and throughput of samples that can be processed in a day, and provide meaningful results consisting of estimates of dry weight, abundances and sizes in near-real time. However, it must be recognized that automatic recognition is only accurate enough for a few zooplankton taxa at this point in time (Gorsky et al. 2010, see Figure 1 for examples). Many also provide concurrent acquisition of other physical and chemical data at sea. Over the term of WG130 an increase in publications of studies using these tool combinations demonstrate how large-scale studies can be conducted and are essential if we are to understand the patchiness of plankton abundance in the world's seas and oceans.

This fourth meeting of our working group afforded an opportunity to improve our understanding of available software and hardware, summarize interim results from ongoing research in the field, and to develop strategies to share and advance automated imaging and processing tools within the aquatic ecology fields. We concluded by reviewing our plans for publication and dissemination of the results of our studies.

Working Group 130 Terms of Reference

1. To encourage the international co-operation of software developers and marine scientists to use and enhance the open-source development platform, so that a common toolset can be built up over time that is of value to the community.
2. To evaluate the limits of taxonomic resolution possible from image-based classifiers and develop means of improving the taxonomic resolution that can be achieved from plankton images. The working group will establish a basis for standards in taxonomic reporting by automatic labeling instruments.
3. To review existing practices and establish standards in the use of reference image data used for training automation machines and in training people.
4. To establish a methodology for inter-comparison/calibration of different visual analysis systems.
5. To develop open-source software for application by the marine ecology, taxonomy and systems developers. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognized, peer-reviewed journal or a book by a major publisher.

Agenda

Wednesday May 26, 2010

Time	Activity
09:00 – 09:30	Welcome, Overview, Logistics
09:30 – 10:30	Brief Progress Reports on Research Topics for Journal Volume Mark Benfield: Rapid sample processing with PICT

	Mark Benfield, Luciana Sartori, Marc Picheral: Zooscan intercomparison study
	Phil Culverhouse: Human performance experiment
	Hans Verheye, Grazia Massochie: Discrimination of morphologically-similar zooplankton
10:30 – 11:00	Coffee Break
11:00 – 11:30	Philippe Grosjean: standard data formats for exchange between instruments
11:30 – 12:00	Philippe Grosjean: Intercalibration of FlowCAMs using Zoo/PhytoImage
	Hans Verheye: comparison of automatically- and manually-derived biomass estimates from scanned zooplankton samples
	Luciana Sartori: A comparison of performance between imaging instruments
	Grazia Mazzocchie: A discussion on the relevance of reference specimens
12:00 – 13:00	Lunch
13:30 – 14:30	Lars Stemmann: A tour of LOV facilities
	Lars Stemmann: Radezoo, a new resource for the ecological modeling community
	Marc Picheral: UVP5 and progress at LOV
15:00 – 16:30	Coffee Break
	Jens Rasmussen: Zooscan Research at the FRS
	Hans Verheye: progress with Zooscan at Cape Town, S. Africa
	Grazia Mazzocchie: using Zooscan at SZN
16:30 – 18:00	Planned dissemination activities: a discussion on:
	ASLO June 2010
	Zooplankton productivity meeting, Pucon 2011
	Census of Marine Life Web site (see http://www.coml.org/investigating/home)
18:00 - 19:00	Aperitifs in the LOV garden, meet the LOV team

Thursday May 27, 2010

Time	Activity
09:00 – 10:30	Special issue discussion and deadlines
	Breakout groups to plan final report
10:30 – 11:00	Coffee Break
11:00 – 12:00	Continue breakout group discussions
12:00 – 13:00	Lunch
13:00 – 15:00	Terms of Reference discussion – key topics
15:00 – 15:30	Coffee Break
15:30 – 17:30	Future Directions, Summary and allocate reporting tasks
19:00	Meet for dinner at Le Cosmo, Villefranche

Brief Progress Reports on Research Topics for Journal Volume

Mark Benfield: Rapid sample processing with PICT

The PICT project is progressing well, with a new version of PICT due for release. A conference paper on the work has been accepted to the ASLO Summer conference in Santa Fe, New Mexico, in June 2010. A set of human sorting experiments is planned for later this year to assess the performance gain with the use of PICT.

Mark Benfield, Marc Picheral, Luciana Sartori: Zooscan intercomparison study

The experiment has not concluded as yet, because of the complex logistics needed to circulate the samples among four different countries in three different continents and delays through customs. The samples are now back in the UK with Phil Culverhouse. Zooscan calibrations at all three sites have been carried out, and all LHPR samples in LH17 and LH19 have been imaged. Specimen images have been processed with Plankton identify and await validation by Bob Williams (to give consistency of labeling) using a protocol developed by Marc Picheral.

Four experiments will be scheduled once datasets have been validated, the purpose of which is to:

1) demonstrate calibration exists between different Zooscan instruments.
2) define error bars (i.e. quantify variance) between abundance estimates across sub-samples of a net haul.
3) compare machine abundance estimates with those obtained by Williams in 1975
4) derive coefficients for dry weight calculated automatically by Zooscan or Zoo/PhytoImage[1] from data supplied by Williams and compare results to dry weight measurements made in 1975.
5) compare abundance measurements made by Williams to those by machine to those by independent ecologists on the same set of sub-samples.

Recall that the purpose of these experiments is to demonstrate the contribution of machines to making sample analysis reliable. This is in several parts, firstly to give confidence to the wider community that the instruments are easy to calibrate and inter-calibrate, secondly to show that the machine abundances (and derived dry weights) show good correspondence to that measured originally, and thirdly to establish that the results from machines show less variation than humans can achieve on the same data.

[1]*Alvarez E, González P, López-Urrutia Á, Díez J, Nogueira E, del Coz J J and González-Quirós R (2010) Automated Classification Techniques Targeted To Improve The Precision Of Biomass Estimates. ASLO/NABS International Joint Summer Meeting, Santa Fe, NM, USA. 6-11th June.*

Phil Culverhouse: Human performance experiment

A set of simple microscope-based experiments has been undertaken in two laboratories that explore the variance within and between participants engaged in visual identification of marine plankton.

These experiments continue albeit delayed by the same circumstances that caused problems for the Zooscan inter-calibration above. However, additional sets of participants have been identified at Hans Verheye's laboratory in S. Africa, at Marine Scotland in Aberdeen and at the Marine Research Institute, Iceland. Culverhouse is exploring opportunities to run this experiment with other members of the ICES community. So far he has found a lack of expertise in laboratories, with some being able to offer only one experienced zooplanktonologist to the experiments. This is insufficient to run his study.

He also reported that a training course on computer-based visual identification of plankton (to be held in September 2009) had to be cancelled. Over forty applications were received, but as 36 of them were requesting full bursaries to attend the course was not viable.

Hans Verheye: comparison of automatically- and manually-derived biomass estimates from scanned zooplankton samples

This also has been delayed as above. Our expected journal articles will be: Lopes, R., R. Williams, H Verheye and C. Davis. Allometric coefficients for zooplankton biomass estimation using automatic plankton analysis. There are three questions to be addressed: (1) Do we have sufficient and reliable allometric relationships covering: (a) most marine zooplankton taxa, (b) all bio-regions and depth layers, and (c) different classification levels (from species to phyla); (2) Are available allometric relationships appropriate to estimate zooplankton biomass from images and what are the constraints of automatic vs manual measurements in different taxa?; and (3) How do we apply coefficients built from microscopic observations to different image types (scanner, video cameras , photography)?

Tasks to accomplish include: collating allometric coefficients from the literature; re-analyzing available data (if possible); identifying major gaps (taxa, region, etc.); investigating the effect of image segmentation on morphometric features of different taxa; correlating microscope-derived coefficients with image features; and comparing results across imaging devices. With respect to comparisons of manual versus automatic measurements: we will use Zooscan images and graphs comparing the prosome length and the major length, as well as total body length and major length of some important groups of the zooplankton.

Hans Verheye: Introduction of ZooScan & FlowCam Technology in Southern Africa: A progress report

The ZooScan was introduced in South Africa, at the then Branch: Marine and Coastal Management (MCM) of the then Department of Environmental Affairs and Tourism (DEAT) in Cape Town, in 2007 following my involvement in SCOR WG 130; a second machine was acquired in 2009. After resolving some serious operability problems experienced with the first

machine, and formal training of several technical staff and students that was provided at the Villefranche and AZTI laboratories, both machines are now in use, fulfilling the needs of a number of ongoing projects in laboratories of the Department of Environmental Affairs (DEA) and the Department of Agriculture, Forestry and Fisheries (DAFF), both in Cape Town.

Within DAFF, the ZooScan is used in pelagic fish research for quick and accurate identification and enumeration of the eggs of anchovy, round herring and sardine from samples obtained from CalVET net collections and CUFES (Continuous Underway Fish Egg Sampler) on the west and south coasts of South Africa. Those data were, until recently, obtained by traditional microscope analysis, and are used to map and to characterize spawning habitat of these small pelagic fish species. It is envisaged that the ZooScan will also be able to identify other fish eggs, such as those of sole, which forms part of an ongoing B. Tech. research project at the Cape Peninsula University of Technology (CPUT) in Cape Town. Seeing that the ZooScan creates vignettes for all other zooplankton present in the CUFES samples besides fish eggs, these analyses will also provide high-resolution distribution maps of near-surface zooplankton taxa.

Within DEA, several projects are contributing to the construction of a reference collection of ZooScan images from both the SE Atlantic and SW Indian oceans. A PhD student at the University of Cape Town (UCT) has initiated a retrospective ZooScan analysis of a multi-decadal archive of microscopically analysed zooplankton samples collected monthly since the 1970s off Walvis Bay in Namibia. A similar analysis of the enormous plankton sample archive of collections in South African waters since the early 1950s is planned for the near future.

A comparison of three different techniques to analyse abundance, size composition and vertical distribution of zooplankton associated with mesoscale eddies in the Mozambique Channel forms the basis of another B.Tech. research project at CPUT. The project aims at comparing results from traditional microscope analysis and ZooScan analysis of depth-stratified samples collected in 2009 and 2010 with a Hydrobios Multinet (200µm), as well as acoustic data collected with a Tracor Acoustic Profiling System (TAPS) mounted onboard the multinet; TAPS is a multi-frequency (265, 420 and 700 kHz and 1.1, 1.85 and 3 MHz) acoustic profiler designed to provide size-based information on the distribution of individual zooplankton organisms.

Recent research by a MSc student at the University of Bremen focused on a comparison of size structure, abundance and biomass of zooplankton collected with a multinet (150µm) in the upper 1000m in the northern Benguela upwelling system and in the tropical East Atlantic in the region of the Angola-Benguela Frontal Zone in 2007 and 2008. A modified EPSON Perfection V 750 Pro flat-bed scanner and ZooImage (v 1.2-1) software were used. The scanner was operated in transparent mode with a frame of 97.8mm x 97.8mm, equivalent to 9234 x 9234 pixels at a resolution of 2400 dpi.

Most recently, colleagues at the National Marine Information and Research Centre (NatMIRC) of the Namibian Ministry of Fisheries and Marine Resources (MFMR) in Swakopmund have acquired a FlowCam, in an effort to overcome problems associated with the high turnover rate of staff, which results in a continual loss of taxonomic skill and cumulative backlogs in the analysis of phytoplankton samples collected during routine monitoring programmes. Objectives include detection of long-term changes in species composition and size structure of coastal phytoplankton communities, including Harmful Algal Blooms (HABs), and ground-truthing of remotely-sensed ocean color from satellites.

Josue Borrego: Discrimination of morphologically-similar zooplankton (reported by Hans Verheye)

The main objective of Borrego's group is to develop algorithms to identify species that are similar to one another in appearance. Their approach is to use training images to build a composite spectral filter, a nonlinear operation to correct, for example, non-uniform background. They need more types of zooplankton images. Both Hans Verheye's and Rubens Lopes' laboratories have manually prepared vials of male and female copepods and then sent them by courier to Josue. Unfortunately, both attempts have resulted in Mexican customs officials destroying the samples. A third attempt by Hans Verheye will be made later this year, but via a USA postal address!

Papers in press or published since the last meeting are

(i) Josué Álvarez-Borrego and Selene Solorza, 2010. "Comparative analysis of several digital methods to recognize diatoms". Hidrobiológica, In Press;

(ii) Selene Solorza and Josué Álvarez-Borrego, 2010, "Digital system of invariant correlation to position and rotation". Optics Communications, In Press;

(iii) Ricardo Enrique Guerrero-Moreno and Josué Álvarez-Borrego, 2009. "Nonlinear composite filter performance". Optical Engineering, Vol. 48, (067201), 26 June;

(iv) Jesús R. Lerma-Aragón and Josué Álvarez-Borrego, (2009). "Vectorial signatures for invariant recognition of position, rotation and scale pattern recognition". Journal of Modern Optics. Volume 56, Issue 14 August, pages 1598 – 1606; and

(v) Ariel Alfredo Padilla Ramírez and Josué Álvarez Borrego, (2009). "Automatic Recognition system of Objects". Digital Scientific and Technological Journal, e-Gnosis, ISSN 1665-5745. On line, 31 December.

Josue's group has developed a software GUI in .NET called SisRec for end user support. Using the GUI you can see images and steps of process in GUI, which makes it simpler. Phillippe asked if there is a command line interface, i.e., non-GUI. This is available on request from the authors.

Philippe Grosjean: Intercalibration of FlowCAMs using Zoo/PhytoImage

The objectives of this study are to: (1) propose a method for using the FlowCAM with Zoo/PhytoImage; to compare results obtained with three different FlowCAMs and three operators using common samples; and (2) assess whether a training set made with one FlowCAM can be used to predict objects isolated by another FlowCAM. See Figure 2 for details of the experiment structure.

The study used three FlowCAMs models made in 2004, 2007, and 2009. Each had the same camera and resolution. In summary, FlowCAMs are intercomparable but require clearly defined protocols to ensure compatibility. FlowCAMs require calibration. The Zoo/PhytoImage software with the FITVIS plugin does a good job in analysis of FlowCAM data including automated classification in this relatively easy example. A training set constructed by the same instrument that is being used as a classifier will work well; however, caution must be used when using classifiers constructed from different machines.

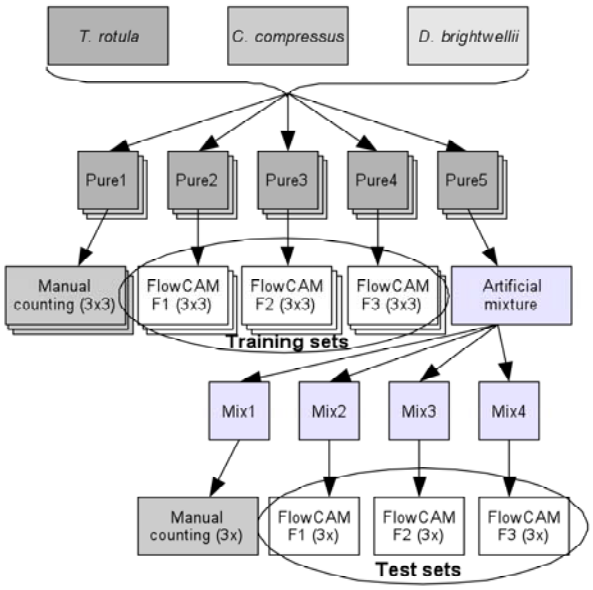

Figure 2: FlowCAM intercalibration experiment structure

Conclusions from the study are that care must be taken when using classifiers from a different FlowCAM, it may work or not, and results are not symmetrical, e.g., F1 classifier gives good results for F2 dataset, but not the contrary! Slight differences in image quality/characteristics

explain this. FlowCAM counts across instruments do not match manual counts for all groups. This is explained by a variation in the shape of the particles, even with a simple and 'safe' design like with our pure cultures/mixtures; successive operations tend to break apart cell colonies and fragile detritic particles. Strictly, there still exists a machine calibration problem for slight changes in the characteristics of the particles between samples and between different digitizing devices.

Analysis is complete, and the manuscript is written and almost ready for publication.

Philippe Grosjean: standard data formats for exchange between instruments
The purpose of this activity was to propose a common, well-documented, flexible exchange format for plankton images, data and metadata. The format does not need to be used internally by each software toolkit, but import/export in this format should be encouraged.

The format specification is restricted to pure technical aspects. It does not specify how the content is obtained (ex: results => no specification of what kind of results should go to the table). For non-technical users, simple open-source viewers will be useful. This concept fits in the Terms of Reference of the SCOR WG130 because it provides a common series of entry points where various Open Source programs could be interconnected. Figure 3 depicts the possible workflows involved in plankton identification, and the entry and exit points of data import or export are shown numbered 1 to 7. Most data are text, either 2D tables or lists of metadata. 2D tables: include csv files, recommendations for field separators, number accuracy, missing data, names of key/mandatory variables.

Metadata accompanying a plankton sample is crucial to the subsequent use of the results of identification process. It is suggested that an open list of recommended metadata be created with mandatory/optional components. See Annex C for details. These could be a starting point for a common metadata between identification tools (for example Plankton Identifier and Zoo/PhytoImage). Where there are many files, optionally, a zipped archive should be recommended (for 2 and 4 in Figure 3).

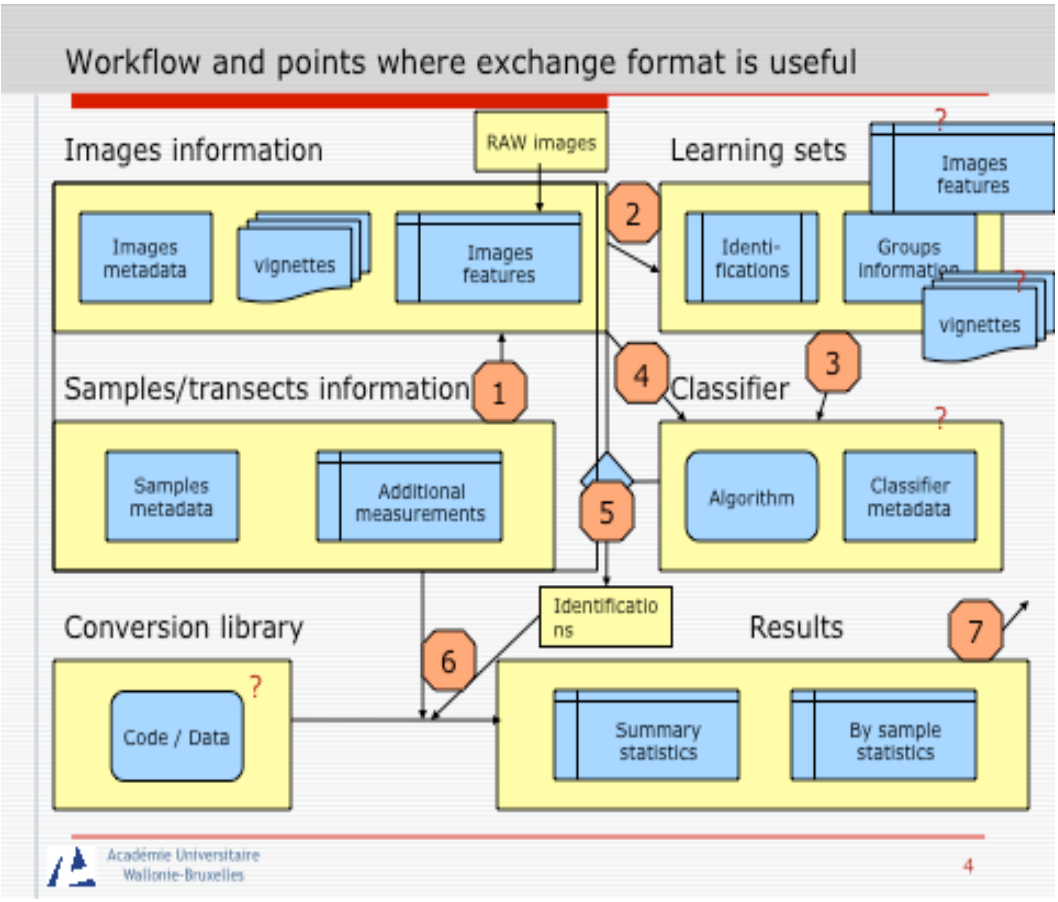

Figure 3: Plankton understanding workflow

Lars Stemmann: RadeZoo and archival data

Safeguarding ZooScan data and metadata and sharing them in a network requires that these be published in digital libraries such as national and/or World Data Centres (NODCs and/or WDCs) that have the capacity to archive and distribute images and their associated metadata. NODCs such as US-NODC in the USA, SISMER in France, and BODC in the UK are designated by the International Oceanographic Data and Information Exchange programme (IODE) of UNESCO's Intergovernmental Oceanographic Commission (IOC), while World Data Centers (WDCs) such as WDC-MARE in Europe, WDC-Oceanography in the United States, Russia, China and Japan are designated by the International Council for Science (ICSU).

Part of the data from the annual time series of zooplankton from the Bay of Villefranche-sur-mer, (http://www.obs-vlfr.fr/Rade/RadeZoo/RadZoo/eng/RadeZoo_eng/Home.html), has been safeguarded at the WDC-MARE and available online by the PANGAEA information system (http://doi.pangaea.de/10.1594/PANGAEA.724540). Zooplankton samples collected daily but pooled in weekly jars are analyzed using the ZOOSCAN the following week, and metadata and some data are immediately visible on the Web site. More than 5000 samples have been analyzed this way. Data are then uploaded to PANGAEA every year following their format. Access to raw

images, log files and data files is password protected, whereas low-resolution images, and key variables such as abundances and biovolumes of copepods and total plankton are publicly available.

With respect to ZooScan data, it is essential that different instruments are inter-calibrated and that software configurations are known. In the frameworks of the SESAME EU integrated project and the CIESM's Zooplankton Indicator program the ZooScan approach is used to build a standardized Mediterranean image bank and a zooplankton experts' network that we hope will grow beyond the Mediterranean in the near future.

The datasets from the ZOOSCAN have a low taxonomic resolution (see http://www.obs-vlfr.fr/gallery/ZooPart) considering the hundreds of plankton species in a given area, but the data are particularly suitable for biogeochemical models that want to increase the number of plankton functional types or zooplankton taxonomic groups or that want to describe zooplankton on the basis of biomass or size spectra.

Marc Picheral: UVP5

There is an urgent need for new tools to monitor and analyze deep ocean processes. We are proposing to use the Underwater Vision Profiler (UVP) mounted on an underwater observatory for long-term monitoring of near-seafloor sedimentation and resuspension of particles and of near-bottom zooplankton populations. The combination of the in situ imaging and measurement system (UVP) with geophysical and geochemical instrumentation will provide a complete picture of the long- and short-term near-bottom events. The use of the identical instrumentation for water column and benthic processes will for the first time link both domains on long time scales.

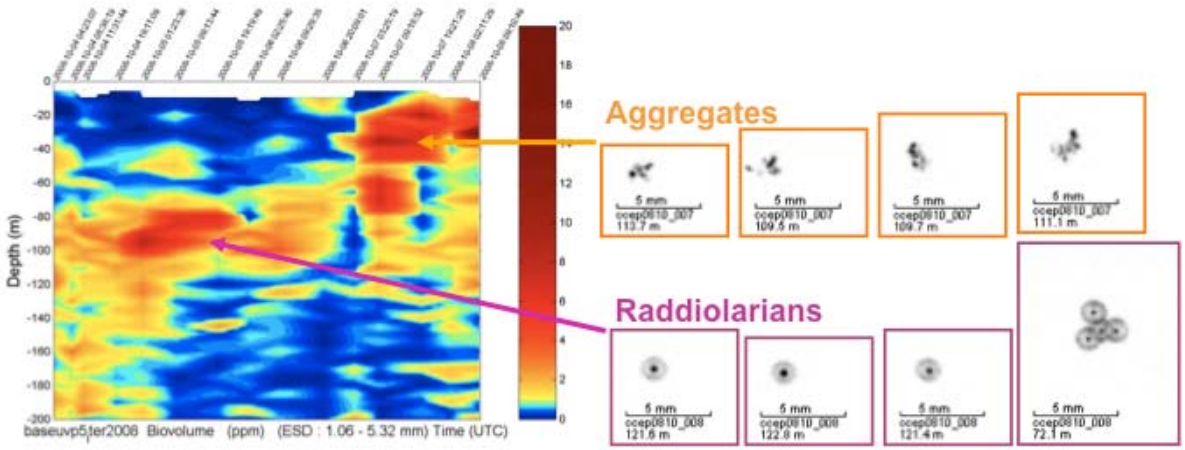

Figure 4: Automatic analysis plots from UVP5

The UVP records images of particles and organisms illuminated in slabs of water that have well-defined volumes ranging from 0.20 liters to 10 liters, depending on the UVP set-up. The analysis

of images using Plankton Identify provides quantitative information on the size and shape of objects in the field of vision of the UVP that can be used to calculate the distributions of particle size spectra, stocks and fluxes in real time. In addition, large plankton (> 2 mm) are identified and their abundances reported. The UVP is adapted for long-term deployments in stand alone or instrumental platform mode. See Figure 4 for a sample of functional groups versus depth plots that are available from the identification software automatically.
The first experience with a cabled subsea observatory equipped with an UVP will be undertaken in 2011 on the Ocean Technology Test Bed connected to VENUS in Saanich Inlet (BC, Canada). The collaboration between LOV and University of Victoria, ASL Environmental Sciences VENUS/OTTB and ONCCEE will allow real-time instrument monitoring, data acquisition and transmission to land and to the collaborating institutions.

	aggregates	copepods_nauplii	diatom_central_single	diatom_chains	dino_ceratium	Radiolarians_other	Spheres	Tintinids	Sum	
aggregates	**853**	136	1	126	73	176	43	86		**1494**
copepods_nauplii	57	**1318**	0	0	111	3	0	11		**1500**
diatom_central_single	44	1	**1145**	5	0	5	287	13		**1500**
diatom_chains	71	1	0	**984**	80	17	0	292		**1445**
dino_ceratium	42	104	0	128	**1052**	1	0	108		**1435**
Radiolarians_other	183	13	0	5	19	**1238**	30	11		**1499**
Spheres	28	0	260	2	0	10	**1187**	13		**1500**
Tintinids	130	18	7	349	91	14	20	**848**		**1477**
Sum	**1408**	**1591**	**1413**	**1599**	**1426**	**1464**	**1567**	**1382**		**11850**

Figure 5: Plankton Identifier: first results from a FLowCAM imaged water sample

FlowCAM has been coupled to Plankton Identify and the first results are shown in Figure 5.

Summary of Breakout Group Discussions

The meeting separated into breakout groups to discuss the following topics: Data Exchange and File standards (parameters and metadata); Reference Specimen Data Sets (type-specimens for machine identification). Summary points developed in these discussions follow.

Data Exchange and File standards (parameters and metadata):

- The issue of standards is complex, since instrument manufacturers want the freedom to develop new ways of representing machine data outputs, yet end-users want a common base so that they can apply any processing algorithm to any data regardless of its source. In a developing field such as this, it is not sensible to constrain the evolution of machine outputs, yet a compromise must be sought to foster adoption of these new technologies in the marine ecology research community.
- The discussions focused around an earlier presentation given by Philippe Grosjean, where he listed the opportunities for data exchange and the formation of common file formats.

- The consensus of the group was that it was sensible to establish an early standardization of metadata between instruments, and that images output from instruments should be in popular storage formats (TIFF, JPEG, PNG, BMP), but that using lossy compression techniques (used in jpeg for example) could result in a loss of critical taxonomic features in the archived vignettes (or Regions of interest - ROI). Other forms of exchange might be feasible but should not be formalized at this point. The DarwinCore2 specification will be extended as appropriate.
- A list of possible suggested metadata for samples, transects, or profiles is shown in Annex C. These could form the basis of user requirements for metadata handling in computer-based analysis of plankton. They will be made available on the SCOR WG130 website for this purpose.

Please refer to annex C for the detailed conclusions of this break-out session.

Reference Specimen Data Sets (type-specimens for machine identification):

- In the 2008 Working Group 130 meeting a proposal for three types of specimen reference was tabled and discussed: the Gold, Silver and Bronze standards.

A proof of process for standards creation will be completed, which will require taxonomists to create gold standard sets for a few key species/genera with sufficient specimens to be used for classifier training. Gorsky (or another) will scan these and produce both Zooscan parameters and vignette images for each gold standard type, and hence produce a silver standard. These silver standards will then be used to instantly extend the identification capabilities of all Zooscans across the world, and also provide images (the vignettes) for other ecologists using flat-bed scanners and ZOOIMAGE or other similar software. Issues to be resolved in this experiment include fixative and staining protocols, the provision of accompanying statistical data of these new standard data set, and means of linking to genetic barcoding.

This is being constructed at LOV as a reference specimen set from which silver standard sets of Zooscan-produced image vignettes are archived.

Please refer to annex D for the detailed conclusions of this break-out session.

Progress against terms of Reference

Working Group 130 Terms of Reference

1. ***To encourage the international co-operation of software developers and marine scientists to use and enhance the open-source development platform, so that a common toolset can be built up over time that is of value to the community***.

   The group has been operating since 2007 and has held four annual meetings, in Hiroshima, Japan; Sao Paolo, Brazil; Baton Rouge, USA; and Villefranche, France. Meetings have always included presentations from commercial hardware developers (Flowcam, Zooscan, UVP), open-source software developers (Plankton identify, Zooimage, matlab toolkit, PICT and PAS) and also end-users from a variety of marine laboratories in addition to members and associate members of Working Group 130. The mix of backgrounds has made for interesting discussions and over time fostered collaborations across these diverse fields. So, as a direct result of the formation of WG130 the laboratories below have established strong links:

   - Louisiana State University, Department of Oceanography and Coastal Sciences, 2179 Energy, Coast and Environment, Baton Rouge, LA 70803 USA
   - Centre for Robotics & Neural Systems, SoCaM University of Plymouth, Plymouth, PL4 8AA. UK
   - Department of Biology, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, USA
   - Numerical Ecology of Aquatic Systems, Mons University, Belgium
   - Biological Oceanography, Marine & Coastal Management (Research, Antarctica and Islands), Rogge Bay 8012, Martin Hammerschlag Way, Foreshore, Cape Town, SOUTH AFRICA
   - Department of Palaeontology, The Natural History Museum, UK
   - CNRS/UPMC, LOBEPM, La Darse, 06234 Villefranche sur mer cedex 4, FRANCE
   - Marine Scotland, Marine Laboratory, Zooplankton Ecology Group, PO Box 101, Victoria Road, Aberdeen, AB11 9DB UK
   - Instituto Oceanografico, Universidade de Sao Paulo, Praça do Oceanografico 191, São Paulo, BRAZIL
   - Shirshov Institute of Oceanology, Russian Academy of Sciences, RUSSIA
   - Optics Department, Division of Applied Physics, CICESE, MEXICO
   - Stazione Zoologica ‘Anton Dohrn’ Napoli, ITALY
   - Bigelow Laboratory for Ocean Sciences, USA
   - Centro Oceanográfico de Gijón, Instituto Español de Oceanografía, SPAIN
   - AZTI (Institute for Fisheries and Food Science), SPAIN
   - JAMSTEC, JAPAN
   - Institute of Oceanology, Chinese Academy of Sciences, PRC

- Plymouth Marine Laboratory, UK
- Sir Alistair Hardy Foundation for Ocean Science, Plymouth UK.

The links have been forged through meetings; joint publications and joint research experiments between WG130 members, associate members and guests to WG130 meetings. This represents a significant proportion of the research community in the domain of computer-based visual identification of plankton.

2. ***To evaluate the limits of taxonomic resolution possible from image-based classifiers and develop means of improving the taxonomic resolution that can be achieved from plankton images. The working group will establish a basis for standards in taxonomic reporting by automatic labeling instruments.***

   Although it is still early days to be definitive in terms of taxonomic resolution, a number of papers have already been published that demonstrate the resolution of image-based plankton identification (please refer to the publications list in annex F).

3. ***To review existing practices and establish standards in the use of reference image data used for training automation machines and in training people.***

   This has been completed in two stages. The first report was tabled to SCOR in 2008, the second and final report is included (see Annex D). The recommendations of this sub-group are a set of plankton taxa that can be monitored using automatic means, and also those that need to be monitored, and for which standard type-specimen collections must be established. Gorsky and others at LOV are constructing an archive of vignettes taken from Zooscan-processed samples. These archives are available as training sets for other Zooscan users. The Ocean Weather Station India samples are being processed in the same manner and will also form a reference data set in the future.

4. ***To establish a methodology for inter-comparison/calibration of different visual analysis systems***;

   Tabled as a group discussion item in year one of the WG130, we now have established both a set of experiments to explore inter-calibration between instruments, but also to define the relationship between machine performance and human performance. Some of these experiments have been delayed by difficulties experienced in transporting plankton across international boundaries, as described above. However, we now are in a position to describe inter-calibrations between FlowCAM instruments through the use of Zoo/PhytoImage, and between a high-resolution digital camera, a scanner with ZooImage and Zooscan using Plankton identify.

   There have been seven inter-calibration papers published since 2003 (see Table 1), All except two have been authored by at least one SCOR WG130 member. Four reviews have been published in this period; all were senior authored by SCOR WG130 members except Morales (2008), who cites the need for automation to cope with the decline of taxonomists in South America. There is also a trend in publications of increasingly large-scale studies, with one global-scale publication in 2008 (Gorsky et al. 2008). We can expect more of these extensive studies in the future. See Annex F for the complete list of papers.

year	total per annum	techniques	intercalibration	local studies	large studies	global studies	reviews	SCOR WG130 members
2003	10	4	1	5				5
2004	6	4		2				2
2005	5	4			1			3
2006	6	3		2			1	3
2007	12	8	1	1	3		1	5
2008	12	5	1	2	3	1	1	5
2009	15	5	2	3	4			10
2010	16	10	2	1	2		1	12

Table 1: Publications relating to automatic plankton identification 2003-2010

5. ***To develop open-source software for application by the marine ecology, taxonomy and systems developers. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognized, peer-reviewed journal or a book by a major publisher***.

There are two truly open-source software toolkits being distributed at present: Zoo/PhytoImage (Gosjean et al. 2004, for example) & ZooProcess/Plankton identify (Gorsky et al. 2010 for example). Both groups acknowledge that metadata is the most important facet of a sample that can form the basis of a common exchange format, both are contributing to the discussions on metadata and standards. It is also acknowledged that the DarwinCore2 metadata definition addresses many of the issues required of an exchange format. Both software toolkits offer links to a range of input devices, including flat-bed scanners, digital cameras, FlowCAM, Zooscan and UVP, for example. A number of SCOR WG130 members and associate members have had published, or plan to publish, inter-calibration and performance issues of these tools.

Four reviews have been published since 2003 (see Table 1); all were senior authored by SCOR WG130 members except Morales (2008), who cites the need for automation to cope with the decline of taxonomists in South America. The first review gave rise to the Research in Automatic Identification of Plankton (RAPID) group, a precursor to SCOR WG130. There is also a trend in publications of increasingly large-scale studies, with one global-scale publication in 2008 (Gorsky et al., 2008). We can expect more of these extensive studies in the future. See Annex F for the complete list of papers.

Review articles offer a way of promoting new ideas and methods in an easily digestible form for people new to the field. We report that Culverhouse et al. (2006) has been cited 16 times, and Benfield et al. (2007) has nine citations with all citations being to new authors. The groundbreaking Tara Oceans Project (http://oceans.taraexpeditions.org) identifies both reviews as defining the requirements of automation. It is too early to assess the impact of Sieracki *et al.* (2009). In her review of Plankton monitoring and analysis in the oceans, capacity building requirements and initiatives in Latin-America, Morales (2008) places computer-based visual identification of plankton into the context of South American marine ecology. Three papers cite SCOR WG130 in their acknowledgements. The working group has also held a special session of

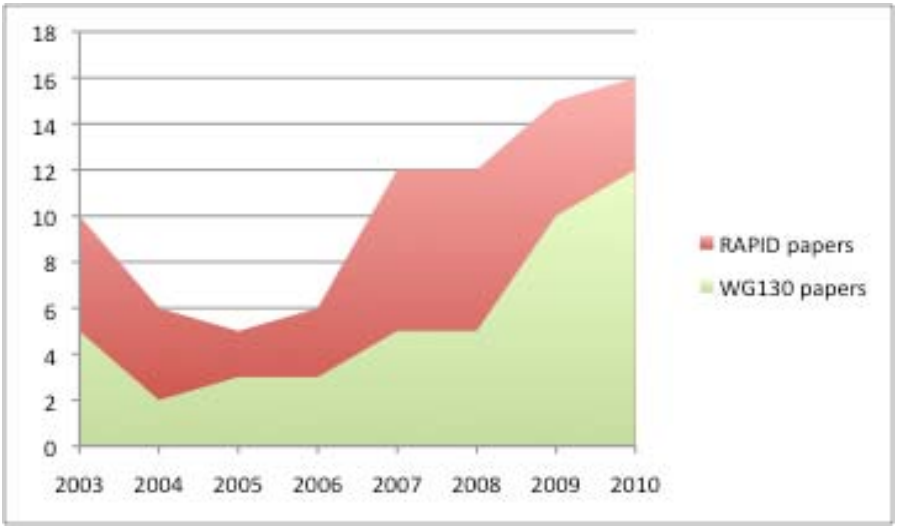

Figure 6: Research in Plankton identification - publications by year

the Summer ASLO/NABS meeting (June 4-9th 2010 Santa Fe, USA) on computer-based visual identification of plankton. Six papers were presented and the session was well attended (see Annex E for details of the conference session).

We acknowledge the delays in getting experimental work completed and analyzed in time for an expected JPR publication in 2010. However, we are in discussions with the editor of JPR on a special issue call. We are also in discussions with book publishers. Finally, WG130 was invited to plan a conference one-day workshop on computer-based visual identification of plankton at the Zooplankton Productivity Meeting to be held in Pucon, Chile in March 2011.

Conclusions

The Working Group has taken time to bond and become productive, but now it is cohesive. The members are becoming clearer in the needs of the wider community and we expect the JPR special issue, the ZPS meeting in Pucon and discussions with a book publisher to continue to raise the profile of computer-based visual identification of plankton. A strength of the group is that we represent both commercial and low-cost methods for automation, which will give both government laboratories and university laboratories in developed and developing countries access to the same quality of computer tools.

It is interesting to speculate on the growth of this field, Figure 6 suggests that we are still at the stage of early adopters to the technology and perhaps on the cusp of wider take-up, given the year-on-year growth in publications since 2005. The productivity of WG130 members and associate members is plotted on the same graph against total publications in the field and indicates that our group is highly productive. The complete publications list will be made available on our SCOR WG130 website. It is also included here in Annex F.

We believe that this working group should continue for another 4-year term, to continue to support the adoption of new software technology and to act as focus for innovation. A strong international effort is required to compensate for the decline in people skilled in plankton taxonomy. Growing the associated membership to fully include all research groups will further strengthen and facilitate growth in this important area.

Next Meeting of WG130

The next meeting of WG130 is currently un-funded, but is likely to be at ZPS, at Pucon Chile, March 2011.

Annex A: List of Participants

Working Group Members and Associate Members

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Annex C: Data standards and exchange formats

In the working group's first term of reference, the encouragement to develop common toolsets through an open-source development platform is advocated. Irrespective of the implementation-specific solutions for various software packages, there is a common need to be able to exchange data at various stages of the image acquisition and analysis process. The only way to encourage developers to participate in the development of tools for image-based analysis of zooplankton is to provide standards for data exchange formats. Standardized data exchange formats should, however, not be so restrictive that they limit development opportunities, and it was generally agreed that a simple set of guidelines for the data exchange formats, such as an ascii text file, comma-delimited with data column names in the first row, would be a suitable shared characteristic for all data exchange formats. However, there is an expressed need to detail the data exchange further if distributed development is to be encouraged (as is common practice in many open-source developments). In addition, there is a need to define metadata that can be transferred from sample libraries through acquired images, and analyzed samples. A set of mandatory fields should be identified (see below) as well as allowing the scope for adding extra optional fields. It is, however, important that the optional metadata field names are also listed to ensure consistent use between toolsets that could be developed.
The discussion on data standards touched on the potential benefits from creating a data exchange format framework. It would potentially allow developers who are experts in developing, for example, classifiers to contribute without having to spend time developing basic sample storage and organization.
A total of 6 data exchange formats were identified through creating a generic image extraction, learning – and classification schema (see Fig. 1). It may also be beneficial to develop metadata standards for learning sets and classifier functions to make collation of such libraries and functions easier.
The development framework presented in Fig. 1 is based on principles of image analysis and classification from existing software packages, like Zoo/PhytoImage, or Zooscan's ZooProcess. However, there are already differences in approaches between existing software that necessitates good documentation in the data exchange formats and the metadata to perform an evaluation of the suitability for a particular type of analysis or operation.
For example, the PICT software solution works on building features directly from the vignettes, so a set of extracted vignettes from ZooProcess or Zoo/PhytoImage would not be immediately useful as they are in lossy compressed jpeg formats, and have bounding boxes and scale bars on the vignettes. To pick up such features, documentation of the extraction routine is necessary through a relatively simple set of metadata, describing the extraction process, and the output image format and features.
It is acknowledged that it may not be possible for every product developed to segregate functionality to a stage where all data exchange formats can be extracted during the process. However, developers should be encouraged to enable the import/export of data between

functional areas in the data exchange formats. The definition of the exchange formats should be relatively open and not constrain development, but rather encourage it.

In the flowchart in Figure 1, the process is started with a collection of sample data, relating to the material to be analysed through image analysis and classification. These data will be important to retain as they become relevant to merge into the final result set, and will also help work as identifiers of image files, vignettes, and feature tables in some software packages. The sample information is interfaced with image acquisition as metadata that is entered (or possibly extracted with a future toolset) from the existing sample data.

The data exchange formats suggested in this framework are mainly incremental, meaning that data is added to a previous exchange format after processing. This approach may add some additional data to transfer between processes in comparison to existing solutions. However, all data in these exchange formats are text-based and will not increase the storage requirements by much, relative to the large volumes of storage required for images. In addition, retention of data from all processing levels will open for the possibility of new analytical tools on learning sets and final data. For example, the retention of original sample data for the particles used in a learning set will allow geographical extent description of taxonomic groups in the learning set. Similarly, all sample outputs will be “geo-tagged” from the original sample data, opening the possibilities of, for example, online map displays of vignettes from a result set. Also, and this point should not be neglected, information about every detail of each process step allows for a better traceability.

The content of each data exchange format (DEF) is not fully finalized and further work will be required, but may possibly be achieved through online collaboration. It will be important to host documentation and model workflows online to allow potential developers access to the information and to ease the possibility of contribution. In Tables 2 and 3, lists of the proposed fields for DEF1 and DEF2 describes the number of potential fields, and demonstrates that the number of fields in the final DEF6 format is likely to be quite high if most of this information is retained. However, with modern software, it is relatively simple to build either optional display of various columns/fields or multiple views of the data in varying levels of detail.

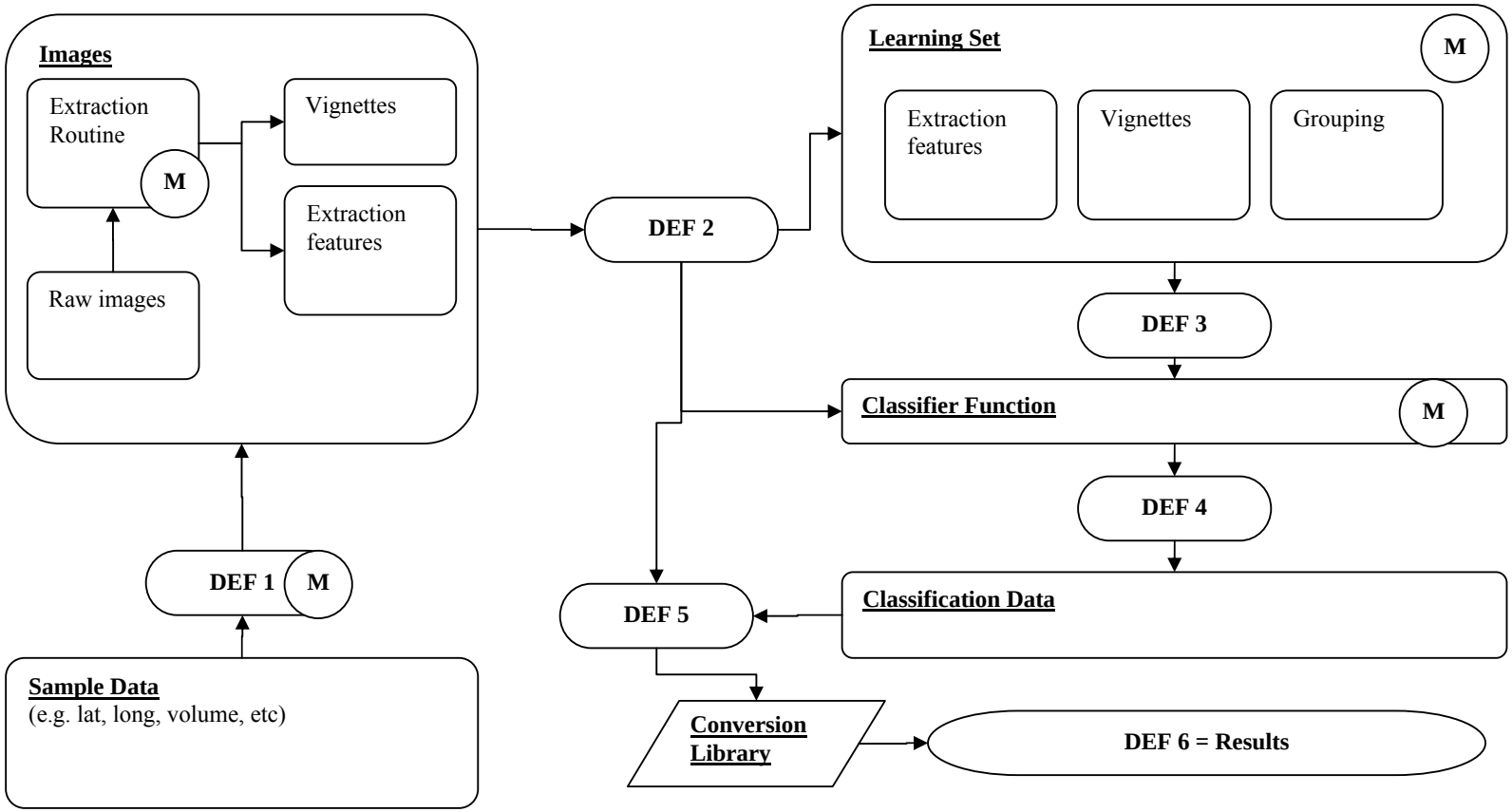
The suggested fields for the first two data exchange formats are listed in Table 1 and 2. These lists are based on existing software solutions and are considered quite exhaustive for the first two exchange formats. However, the additional exchange formats would still have to be worked up in an open, collaborative environment, accessible for developers and users.

Figure 2 illustrates functional overlap areas of existing solutions, and how they almost already meet at the points where data exchange formats interlink functionalities in the image analysis and identification process. The figure also highlights the many different formats of image acquisition already, and underlines the complexity of arriving at common standards for development across an area that spans many different hardware technologies as well as different software solutions.

The proposal of this framework is not intended to discourage current development, nor to call for retro-fitting necessarily. However, it will be highly beneficial for future open source development projects to facilitate close collaboration between multiple developers with strengths

and specialisation in different areas (such as databasing, image extraction features, classifiers, biometric conversion, etc.). If future versions of existing software solutions would consider supplying/exporting data in one or more of the data exchange formats, it may open opportunities for bolt-on products to be created, strengthening the suite of solutions available for scientific users.

It is recommended that software development members of the SCOR WG130 continue the task of defining the data exchange formats. Ideally, this would also include scientific users, and could be achieved through online collaboration. If additional funds can be located for establishing a working group for this task, it would be highly beneficial, although the development should be done openly and with the possibility of other developers/scientific users to register their requirements from such formats (e.g. through online collaboration).



Annex C, Figure. 1.

Generalised workflow of image acquisition, learning set building, classification and conversion of data to achieve the automated identification. Each Data Exchange Format (DEF) illustrates areas that would benefit from having standardized formats with mandatory fields defined. M denotes metadata descriptors or formats.

ANNEX C, Table 1: suggested metadata for samples, transects, or profiles (DEF1):

Key	Required?	Description
Sample	yes	The sample *unique* identification (incorporating date and time in this ID helps in retrieving the sample)
Station	no	The station code or identification, if any
Date	yes	The date of sampling (in yyyy-mm-dd format).
Time	no	The time of sampling (in hh::mm::ss). Fractions of seconds are accepted, if required.
TimeZone	no	The time zone (lag from GMT in +/-x hours). If not provided, time is assumed to be in GMT
Latitude	yes	The latitude of sampling (in decimal degrees, that is, +/-x.xx).
Longitude	yes	The longitude of sampling (in decimal degrees, that is, +/-x.xx).
CoordsPrec	no	Precision of latitude/longitude (radius of the circular zone around the coordinates where the true point probably stands, in m).
Operator	no	Who collected this sample?
Institution	no	The institution that owns the series, i.e., where original biological material is stored, if any
Contact	no	The name of a responsible person for the biological material
Email	no	The email address of the contact
URL	no	An optional URL pointing to a Web page that further describes the sample, series, transect, profile, if any
Note	no	A short general comment (anything you want)
Project	no	The project in which this sample is included (scientific program)
Ship	no	The name of the ship, if any
ShipCallSign	no	Immatriculation of the ship, if any
Coordinator	no	Name(s) of the scientific coordinator(s) on board
Depth	no	The bottom depth at the sampling location (in m). This does not apply to a transect or a non-vertical profile, where there are several bottom depths
GearType	no	The type of gear used to collect the sample
NetOpening	no	The opening area (if collected with a net, in m^2)
NetMesh	no	For a net only, size of the mesh at cod-end (in µm). If different from the net mesh size, this

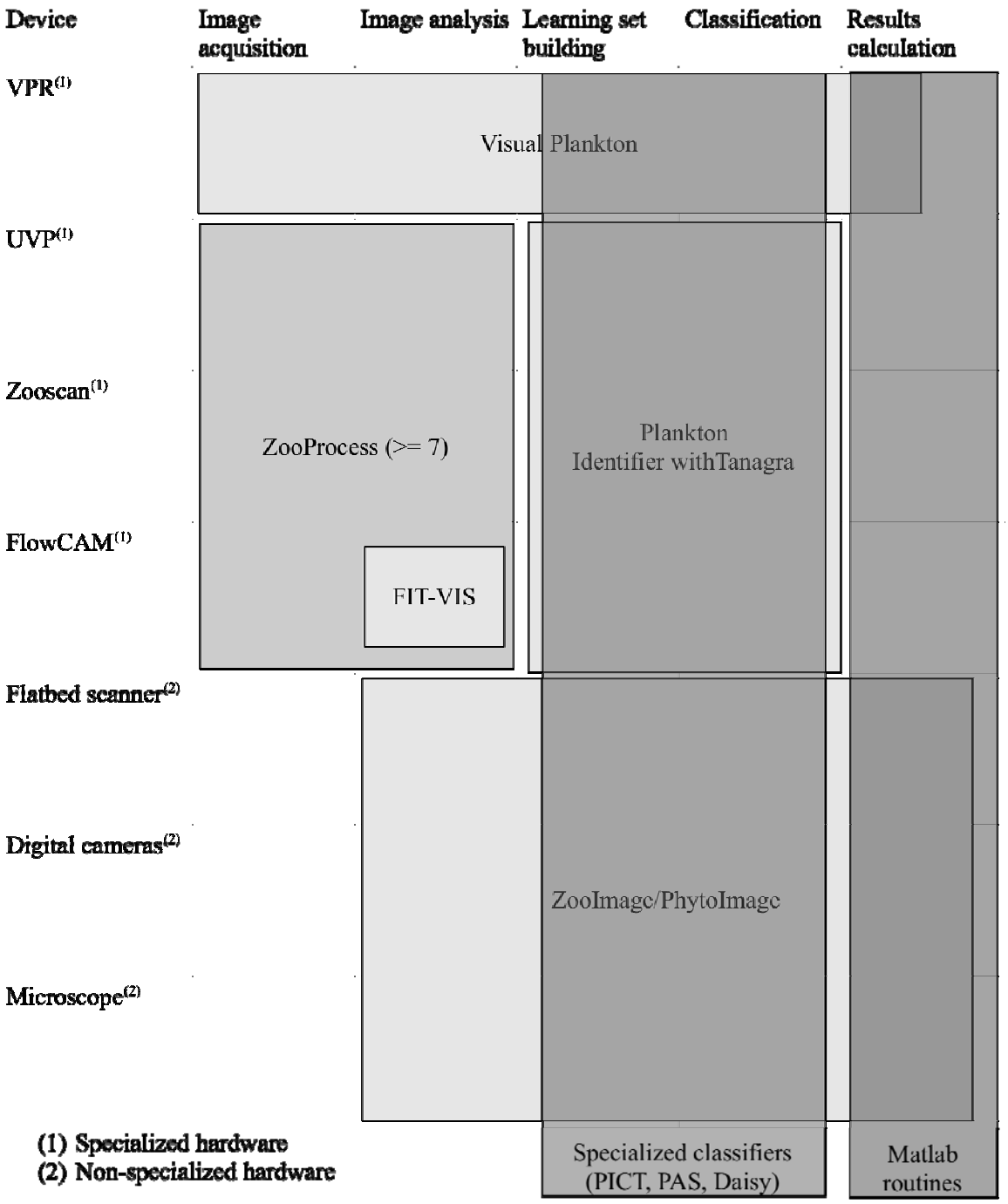
		should be specified in GearType field, or in Note
DepthMin	no	Minimum depth of sampling (in m)
DepthMax	no	Maximum depth of sampling (in m)
SampleVol	no	Volume of seawater sampled (in m^3). For a net, as calculated from the flowmeter reading, or estimated using NetOpening and tow length
SampleVolPrec	no	Precision of sampled volume: SampleVol +/- SampleVolPrec (in m^3)
Replicates	no	The number of replicates, e.g., Niskin bottles, paired nets, etc.
TowType	no	Type of tow (vertical, horizontal, oblique, surface, bottom, ...)
TowSpeed	no	Speed during tow (in m/s)
Weather	no	Weather conditions during sampling. Essentially the state of the sea (e.g., in Beaufort), and the sky conditions (sunny, cloudy, rain, etc.)
Preservative	no	Preservative used (for instance, buffered formaldehyde 4%, or lugol 1%)
Staining	no	Staining used (if any, e.g., haematoxylin, eosin, ...)
CTDreference	no	The reference of the CTD used during the sample collection
CTDURL	no	The link to retrieve the CTD data. Could be a filename, a web URL, etc.
Temperature	no	Temperature of the water at sampling (in °C)
Salinity	no	Salinity of sampled water (in PSU)
Note	no	A short general comment (anything you want!)

ANNEX C, Table 2. Suggested metadata for image analysis (DEF 2):

Key	Required?	Description
Sample	yes	Same as previously
ImageAuthor	no	Who digitized the image(s), or is in charge of manipulating the digitizing device (underwater video, etc.)
ImageHardware	no	Device (manufacturer, model, version) used
ImageSoftware	no	Software used to acquire the image, including version
ImageType	no	A summary of image type (transparency/reflective, number of bit per pixel, color/grayscale, dot per inch, ...)
...	no	Further parameters characterizing the image, for instance, extracted from EXIF data (shutter, ISO, focal, ...). Prefix these fields preferrably with 'Image', like ImageISO, ImageFocal, ...
FractionCode	no	The code of the fraction of the sample that is digitized (if the sample is fractionated by separating large and small particles with a mesh, or any other size fractionation process. If not provided, the sample is assumed to be *not* fractionated.
FractionMin	no	Minimum mesh size for fractionation (in µm), or -1 if not applicable
FractionMax	no	Maximum mesh size for fractionation (in µm), or -1 if not applicable
SubPart	no	The part of the fraction that is analyzed (subsampling, in volume/volume ratio, or weight/weight ratio). If not provided, the whole fraction is assumed to be digitized
SubMethod	no	Method used to take the SubPart of the fraction (Motoda, Falsom, volumetric, ...)
DigitizedPart	no	The fraction of the SubPart that is actually digitized. For devices like the Zooscan, this value is always 1, but for other devices like the FlowCAM, it is a fraction < 1 in autoimage mode, for

		instance
AnalysisMethod	yes	The method used to analyze the sample (e.g., name of a method selected in the software, or reference to a methodology paper that describes it)
AnalysisSoftware	yes	The software and version used
AnalysisSizeMin	no	The minimum size of the particles analyzed (size filter), in 'AnalysisPixelUnit' unit; use -1 or do not provide if not applicable
AnalysisSizeMax	no	Idem, but maximum size; use -1 or do not provide, if not maximum size filter is used
AnalysisSizeVar	no	The variable used for size filtering (area, Ferret's diameter, equivalent spherical diameter, ...)
AnalysisFilters	no	Short description of other filters applied to select particles (e.g., aspect ratio, minimal pixel value, etc.)
AnalysisPixelSize	yes	The size (width) of one pixel in AnalysisPixelUnit unit. If not provided, no spatial calibration has been done (not recommended). This is the same as specifying 1 and 'pixel' for unit
AnalysisPixelUnit	no	The unit used to measure a pixel (µm, mm, etc.). In the (not recommended) cases where there is no spatial calibration, use 'pixel'
AnalysisPixelRatio	no	The pixel aspect ratio (width/height). Assumed to be one, if not provided
...	no	

ANNEX C, Figure. 2. Summary diagram of the various free (public domain, open source, etc.) plankton image analysis software ('results calculation' is calculation of abundances, biomasses, size spectra, etc.).



Web sites for the various cited software:

(1) Daisy: http://www.tumblingdice.co.uk/daisy/
(2) FIT-VIS is integrated in ZooImage to analyze FlowCAM data, see ZooImage
(3) PAS/PICT: http://vis-www.cs.umass.edu/~smurtagh/index.html
(4) Plankton Identifier: see ZooScan web site at http://www.obs-vlfr.fr/~gaspari/Plankton_Identifier/
(5) Visual Plankton: contact Cabel Davis (cdavis@whoi.edu)
(6) ZooImage/PhytoImage: http://www.sciviews.org/zooimage/
(7) ZooProcess: see ZooScan web site at http://www.obs-vlfr.fr/

ANNEX D:
SCOR WG 130: Automated Visual Plankton Identification

Subgroup on 'The Establishment of a Reference Dataset'

Subgroup membership:

- Elena Arashkevich (full WG member, Russia)
- Phil Culverhouse (WG co-chair, United Kingdom)
- Gabriel Gorsky (associate member, France)
- Maria Grazia Mazzocchi (full WG member, Italy)
- Priscilla Licandro (associate member, United Kingdom)
- Hans Verheye (full WG member, South Africa)

Part to be included in the Report from the SCOR WG 130 meeting
held in Villefranche-sur-mer in May 2010

AIM

Providing guidelines and standards for the establishment of a global, validated reference dataset of machine-generated images ('image bank') of plankton taxa. A likely long-term goal will be the training of a new generation of plankton taxonomists using these resources.

Specific objectives:

1 - *To identify which plankton taxa should be targeted in order to promote and expand a global reference collection of images.*

The experience gained over the last three years within and outside this Working Group has demonstrated the great potential that digital imaging systems (e.g., FlowCam, ZooScan, OPC, UVP, other devices) have for the automated or semi-automated analysis of plankton samples, in both lab and field observations. The image quality has notably improved, as well as the procedures for organizing proper learning sets, to the point that plankton identification can be made at the level of broad taxonomic groups. Actually, the image quality is generally high enough that it often allows expert taxonomists to identify the organism vignettes at the level of species and even developmental stage. However, this high level of recognition is still not achievable automatically by machines. This is because of the high probability of contamination due to the limitations of learning algorithms that do not yet allow the machines to distinguish

specific, but subtle, characters. Only in the case of samples with low diversity or clear dominance of monospecific groups, can the digital imaging system provide taxonomic identification at species level. On the other hand, various ecological issues (e.g., long-term monitoring, trophic webs) can be approached by analysing the community structure at broad taxonomic/functional group resolution. At present, the following plankton groups that are of ecological relevance can be automatically identified by imaging systems, with an accuracy that varies between 9 and 93% (Grosjean et al., 2004; Gislason & Silva, 2009; Irigoien et al., 2009):

- Copepoda: Calanoida, Cyclopoida (*Oithona*), Poecilostomatoida, Harpacticoida)
- Malacostraca (e.g. Euphausiacea, Decapoda)
- Amphipoda
- Cladocera
- Ostracoda
- Pteropoda
- Chaetognatha
- Thaliacea (salps, doliolids)
- Larvacea/Appendicularia (e.g. *Oikopleura*, *Fritillaria*))
- Siphonophora
- Polychaeta
- Gelatinous zooplankton (Medusae, Ctenophores), and
- Dinoflagellates
- Diatoms
- Tintinnids
- Radiolarians
- Foraminifera

The taxonomic resolution is likely to be refined as future advances in machine-assisted identification techniques are being made. For instance, some matched-template optical methods such as that illustrated by Josué Borrego (Guerrero-Moreno and Álvarez-Borrego 2009, Álvarez-Borrego and Solorza (2010) and in use in his laboratory are promising for identifying species and even gender and developmental stage within a species.

In the future it would be desirable to include Acantharia and benthic larvae identification as well as moults such as barnacle appendages. This will not only stop them occurring as false positives but also be of great use to benthic biologists, especially as these systems are deployed on long-term observatories.

2 - *To establish, for each taxon, which features should be taken into account in organism morphology and image features for unambiguous automatic identification of organisms; in other words, towards a 'new practical' (automatic and necessarily simplified for now) taxonomy.*

The features commonly used for taxonomic identification under a microscope are clearly different from those utilized by machines and these can be organized in practical guides (identification manuals). The reference animals sorted by taxonomists are preserved in formaldehyde. We recognize the need of such a manual and recommend that financial and human resources be made available for this project, which could be in the form of a master student project under close supervision of a taxonomic expert.
The basic attributes that are presently taken into account are the following: size (the major axis of the best fitted ellipsoid = body length, the minor axis of the best fitted ellipsoid = body width), general shape (roundish, elongated, thin, segmentation, presence of appendages), body pattern (e.g. surface smooth, serrated, ciliated), grey scale coloration (transparency), surface area, surface area excluding holes.
This would help to broaden the use of digital imaging systems for different ecological research purposes, such as the monitoring programmes.
Such a practical manual could be appended as an annex to the User Manual that comes with any given machine-aided identification device (e.g. FlowCam, ZooScan, etc.). This annex should contain many vignettes of organisms viewed from different angles for illustrating each of the taxonomic groups listed above (e.g., Copepoda Calanoida), preferably accompanied by simple line drawings pointing to key descriptors, with some brief explanatory notes.

3 - *To establish which type of dataset should be considered that will ultimately constitute a global reference collection of images for each targeted taxon (e.g. dorsal, ventral, lateral views; adults, juveniles, larvae).*

The dataset should be as inclusive as possible to include all likely species belonging to a given taxonomic category (e.g. Copepoda Calanoida) within a geographical region (e.g. North Atlantic, South Atlantic, Mediterranean, etc.). All possible body aspects/orientations are necessary to be depicted because organisms in the scanner tray or in the field of view of other devices (e.g., FlowCam, OPC, UVP) are spread in unpredictable positions that cannot be forced by the user. All developmental stages that are likely to occur in the samples should be considered because of their occurrence in natural plankton samples.

4 - *To determine the minimum requirements in terms of the number of images related to the image source that is needed per taxon to be recognised unambiguously by machine-based recognition systems.*

It has become clear that the minimum number of images necessary to sufficiently illustrate a given plankton group cannot be established *a priori* and be common to all taxonomic groups, because it depends on the complexity of morphological features characterizing a given taxonomic category. For examples, based on experience, a much higher number of images is

required for automatic identification of copepods and euphausiids than for ostracods, forams, or chaetognaths. It is common to require at least 40-50 specimens per category with machine current learning techniques.

5 - *To promote and contribute to an inter-calibration process among different machines and systems.*

A lot of work has been done over the last few years for inter-calibrating machines and systems and this work is illustrated in the reports tabled for this meeting by Philippe Grosjean and also by Luciana Sartori. These reports are being prepared for publication.

6 - *To promote a worldwide network of taxonomic experts who work in close collaboration with the end-users of automatic recognition systems, including the linking up with certain other ongoing initiatives*

Although we did not establish - on purpose - an official network of taxonomic experts, various activities undertaken in the framework of SCOR WG130 have promoted vivid exchange and fruitful interactions among people working in the field of plankton taxonomy and ecology by using traditional microscope techniques and automatic recognition systems. It would be important to assemble in one mailing list members of the different groups acting under the cover of different structures such as ICES for the North Atlantic, PICES for the Pacific, MedZoo for the Mediterranean, and more generally the community active in the CoML. Another consideration is that if identification will be limited to family or genus then a true taxonomist may not be needed. We suggest that perhaps people working on stomach contents might be a good example as they are more used to identifying animals from a small number of visible parts.

7- *To explore future prospects for the further development, or expansion, of this image dataset.*

A considerable dataset (imagine archive) of zooplankton images has been built by Gaby Gorsky and Marc Picheral with collaborators at LOV in Villefranche-sur-mer, based on sample analyses with the ZooScan. This dataset is mainly based on Mediterranean zooplankton, but it is going to be expanded with the acquisition of images from other scientists working in different geographical regions/seas, oceanographic systems, and/or basins (e.g., North Atlantic, tropical Atlantic, North Pacific, Southern Ocean, North Sea, Baltic Sea, Mediterranean Sea, Black Sea, Benguela Current, Mozambique Channel, etc.). This collection could be considered an initial set for a global digital archive.

There are systems presently in use, i.e., the Underwater Digital Holocamera at Cabell Davis's lab in WHOI, and the SPIM at EMBL in Heidelberg, which allow the reconstruction in 3D images of

planktonic animals (e.g. copepods) with good resolution of *in situ* animals (in the case of UDH) or preserved animals with both external and internal body structures (in the case of SPIM). These are excellent examples of future expansion of an image dataset. However, for the time being we have decided to keep the two levels (2D and 3D) separate and focus only on the practical use of 2D devices like scanners for sample analysis and plankton recognition on a routine basis.

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S41 Computer-based Visual Identification of Plankton

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Please click on the title of an abstract to view the complete abstract.

Oral Presentations

10:30
Bachiller, E; Fernandes, J; Irigoien, X; A COMPARISON BETWEEN DIGITAL CAMERA AND SCANNER AS IMAGING DEVICES FOR SEMI-AUTOMATED ZOOPLANKTON CLASSIFICATION USING MICROSCOPE CLASSIFICATION AS CONTROL (Abstract ID:6141) o

10:45
Denis, K; Grosjean, P; ORIGINAL METHOD TO OPTIMIZE GROUPS IN AUTOMATIC PLANKTON CLASSIFICATION, APPLIED TO NORTH SEA PHYTOPLANKTON USING ZOO/PHYTOIMAGE (Abstract ID:6862) o

11:00
Mattar, M; Murtagh, S; Hanson, A; PICT AND PAS: SENSOR AGNOSTIC TOOLS FOR PLANKTON IMAGE CLASSIFICATION (Abstract ID:7132) o

11:15
Kraberg, A C; Spindler, H; Raabe, T; Wiltshire, K H; REGULAR ONLINE ARCHIVAL OF IMAGES AS METADATA FOR PLANKTON TIME SERIES (Abstract ID:6927) o

11:30
Alvarez, E; González, P; López-Urrutia, Á; Díez, J; Nogueira, E; del Coz, J J; González-Quirós, R; AUTOMATED CLASSIFICATION TECHNIQUES TARGETED TO IMPROVE THE PRECISION OF BIOMASS ESTIMATES (Abstract ID:6820) o

11:45
Hunt, C D; Nelson, H; Michelin, D M; Curran, P; Neal, M; Chitwood, C; Sieracki, C K; IN SITU CHARACTERIZATION OF PHYTOPLANKTON COMMUNITIES USING A NOVEL SUBMERSIBLE IMAGING FLOW CYTOMETER - FLOWCAM (Abstract ID:7167) o

Annex F: Publications in the domain of Research in Automated visual Plankton Identification, since 2003.

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2.2.7 WG 131: The Legacy of in situ Iron Enrichment: Data Compilation and Modeling (2007)

Terms of Reference:

- Compilation of a database for open access (via the Internet) of the following experiments:
  - the 1999-2001 era (IronEx-1, IronEx-2, SOIREE, EisenEx, SEEDS-1), plus 1992 S.O. JGOFS;
  - the 2002 experiments (SOFeX-North, SOFeX-South, SERIES); and
  - the 2004 experiments (Eifex, SEEDS-2, SAGE, FeeP), plus natural fertilizations CROZEX, KEOPS

This effort will include a commonly agreed data policy for users to best acknowledge the original data producers (e.g., by offering co-authorship and perhaps assignment of digital object identifiers for individual data sets). Obviously, a practical description of methods used, calibration etc. (so-called metadata) will also be included. In essence, the WG members are committed to send their data files to the common data centre, and encourage their colleagues in any given experiment to do the same. Finally, an official data publication or publication(s) will be placed in a suitable venue, for example, in the special issue on the SCOR WG (see item 4. below) and in *Eos* (Transactions Am. Geophys. Union). In 2006-2007 efforts are already underway for compilation and rescue of the EisenEx dataset, also there is very good progress for SEEDS-2, SERIES, CROZEX and KEOPS. However, the statement in the original proposal that no meeting would be necessary to achieve the first term of reference was overly optimistic. It appears that a face-to-face meeting sponsored by SCOR or some other internationally recognized organization is necessary to work out the details of bringing together the data sets in a way that will make it possible to achieve the other terms of reference.

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Annual SCOR WG 131 report

This years report is divided into three sections:
Data rescue
Launch of the Database
Planning of Synthesis & Modelling workshop

Data Rescue
This component of the WG has continued this year, and has recently been supplemented with the recent submission of a CD of datasets from the SEEDS II experiment (which was held back until the publication of their dedicated volume (December 2009, *Deep Sea Research II*). Another issue that has been overcome was the reconciliation of inconsistencies in vessel positions from some of the SERIES datasets. Thus, at the time of reporting most of the available data for IronEX I and II, SOIREE, Eisenex (on PANGEA), SERIES, SEEDS I, SAGE, SOFEX-N, SOFEX-S, and SEEDS II have been collated. Regrettably, due to an ongoing data release embargo virtually no data are available from the EifEX experiment. A list of the remaining few missing datasets has been collated and will be followed up in the next few months by Dr. Doug Mackie's successor, Dr. Evelyn Armstrong.

Launch of the Database
The database of ocean iron enrichment studies that is housed at BCO-DMO (Woods Hole) was launched in both the United States (Ocean Sciences meeting, Portland, Oregon, February 2010) and at the European Geophysical Union meeting in Vienna in April. In brief, the U.S. launch attracted more than 20 people who were introduced to the database through presentations by Philip Boyd and Cyndy Chandler. Fei Chai, an iron biogeochemistry modeller, provided a critique of database at this launch, which has provided valuable feedback to BCO-DMO to streamline the database. A full report of this U.S. launch is provided in Appendix 1. The European launch was carried out by Dorothee Bakker in a 12-minute talk at the EGU meeting on 5 May 2010. The presentation was attended by approximately 100 scientists and triggered many questions on SCOR WG-131 and storage of scientific data in general.

Bakker, D.C.E., P.W. Boyd, 05/05/2010. The Legacy of in situ Iron Enrichment Experiments: Data Compilation and Modelling in SCOR WG131. SOLAS/IMBER session. European Geophysical Union, Vienna, Austria.

A weblink to this database will reside on the new GEOTRACES Web site that is currently being revamped by Elena Masferrer at the GEOTRACES IPO.

Planning of Synthesis & Modelling workshop
This workshop is scheduled for mid-2011, and we have brought together the following organizing committee drawn from 7 countries and with a range of skills encompassing modeling (Moore, Fujii, Chai, Schlitzer, Lancelot), synthesis (Moore, de Baar, Boyd, Schlitzer, Bakker) and remote sensing (Westberry):

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Dorothee Bakker UK (d.bakker@uea.ac.uk)

A Web link to this workshop planning group and their interests and a repository of relevant literature will reside on the GEOTRACES Web site.

At present, we are having discussions regarding obtaining additional funding to support this workshop. So far we may have up to 10-15K Euro of potential funding over and above that from SCOR. Several venues in Europe have been investigated (KNAW (Amsterdam), Kiel). There is also the possibility of linking the workshop to that of a GEOTRACES modeling workshop and we have had discussions with Reiner Schlitzer on this matter.

We plan to have a published outcome from this workshop, either as an overview paper in an international journal, but more likely to be a series of linked papers that present different facets of synthesis, modeling and remote-sensing based on the legacy of this WG 131 database.

Philip Boyd & Dorothee Bakker

Appendix 1

Report on the Launch of the WG 131 - sent to Ed Urban on 14 April 2010
Portland, Oregon Sunday 21 February 2010

Participants

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The workshop commenced with two introductory talks by:

Philip Boyd
"Launch of SCOR WG 131 database on open ocean iron experiments"

Cyndy Chandler & Steve Gregg

"Iron Synthesis Database"

Boyd presented the rationale behind and motivations of this working group. Cyndy Chandler then provided a step-by-step guide through the construction and use of the database that resides at BCO-DMO (http://data.bco-dmo.org/jg/serv/BCO/). This included illustrative examples of Project and Data Directories, the status of data rescue for each project, and tools that are available to manipulate data.

There then followed some general discussion on topics such as the mismatch between the amount of rescued data on BCO-DMO relative to that collected by Doug Mackie (SCOR-funded to actively pursue data from these experiments); the need to make better links between BCO-DMO and the PANGEA database (which houses most of the files from the Eisenex study); issues surrounding the use of quality flags in ODV (such as different flags for different properties); the need with some properties such as mixed-layer depth to be clearly and carefully defined (for example Levitus criteria versus Brunt-Vaisala frequency).

Another issue that was discussed in detail was the need to detail parameter format, adopt a core set of parameters and to set up a community-wide accepted vocabulary list for this database. It was suggested that a questionnaire could be used as a tool to construct and define such a vocabulary. The issue of the eventual inclusion of the 2 natural iron enrichment studies in the Southern ocean – CROZEX and KEOPS – was also raised. Hugh Venables reported that much of the CROZEX data had already been collated at BAS and sent to the UK national data centre at BODC. This was also the case for KEOPS via IFREMER. Fei Chai then presented the following talk which provided invaluable feedback to the team at BCO-DMO on the pro's and cons of the present version of this database.

Artur Palacz & Fe Chai

"Biological and Chemical Oceanographic Data Collection – strengths and weaknesses with respect to modelling application purposes"

Their critique dealt with both with geospatial and text-based access. They provided detailed feedback on geo-spatial access. For example, they liked the "quick and easy search engine for programs, projects, deployment platforms and specific parameters"; but thought that "navigation through data results is hindered by small font and too many links clustered in one box". They also made useful recommendations such as "grouping data results into categories related to either different platforms, disciplines or parameter types."

Fei then presented the results of some recent modeling studies that examined the lateral dispersal and penetration (by vertical diffusion) of a 400 km * 400 km ocean iron fertilization over 160 days. This is the type of modeling study that we hope will be presented at next year's planned OIF synthesis and modeling workshop, and we plan to solicit a planning committee comprising both the modeling and the synthesis communities.

We thank Ed Urban, Cyndy Chandler, and Fei Chai and Artur Palacz for logistical support and advice, a fruitful collaboration, and invaluable feedback on the database, respectively.

Philip Boyd and Dorothee Bakker

Co-chairs WG 131

2.2.8 SCOR/LOICZ WG 132: Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems

(2007)

Terms of Reference:

1. Integrate the existing IOC-HAB database and nutrient loading databases into a compatible GIS format.
2. Advance the development of a GIS coastal typology database.
3. Interrogate the above databases for relationships between HAB species, nutrient loading/forms/ratios, and coastal typology and develop broad relationships between nutrient loading and distributions of specific HABs.
4. Explore possible changes in HAB occurrences in the future (year 2030), using the relationships developed above (3.) and global nutrient export patterns under the Millennium Assessment scenarios for 2030.
5. Publish the results of these analyses in peer-reviewed scientific journals. Papers will be developed on 1) the global perspective, including the next generation of global nutrient and HAB maps; 2) regional highlights; and 3) individual case studies. We will also develop articles for the GEOHAB newsletter and for the GEOHAB and Global News websites, and a graphic-rich report (under the GEOHAB umbrella) that will be targeted for management.

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Executive Committee Reporter: Jorma Kuparinen

Progress report of SCOR/LOICZ Work Group 132

Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems

For the period July 2009-June 2010

Patricia Glibert, University of Maryland Center for Environmental Science
Lex Bouwman, Netherlands Environmental Assessment Agency
Working Group Co-Chairs

This report is organized as follows:

I.	Progress of the work
II.	Goals and issues for discussion for the third working group meeting (November 2010, Greece)
Annex A	The terms of reference and key research questions
Annex B	Members of the working group

I. PROGRESS OF THE WORK

SCOR/LOICZ Working Group 132 had its second meeting in 13-16 October in Beijing, and a meeting of a number of group members was in Nyborg, Denmark, 15-18 June 2010. The major hypothesis that this Working Group is testing is that increasing frequency and geographic distribution of HABs is at least in part due to nutrient pollution. Nutrient pollution from land comes via rivers from the runoff and leaching of nitrogen and phosphorus from fertilizers and manure and from sewage water. One source about which we know very little on the global scale is aquaculture. Both shellfish and finfish mariculture are currently increasing rapidly in many parts of the world, particularly in Southern and Eastern Asia. Key progress of the WG includes:

1. Estimating nutrient export to the coastal zone has been a challenge, but enormous advances have been made with respect to global models over the past several years. The working group uses the annual global river export data for sediments and different forms of carbon, nitrogen, phosphorus and silica from the IOC Global Nutrient Export from WaterSheds (Global NEWS) (Seitzinger et al., 2010). The Global NEWS data cover the period 1970-2000, and the period 2000-2050 is based on the Millennium Ecosystem Assessment (MEA). In the past year the working group developed monthly estimates of river nutrient export based on river discharge.
2. The river nutrient export data were complemented with worldwide estimates for nutrient release from shellfish and finfish aquaculture for 1970, 2000 and the MEA scenarios. A simple model was developed by the working group on the basis of available literature data on the various types of feed used in the different aquaculture systems, feed conversion ratios and assimilation efficiencies. Results indicate that shellfish aquaculture may release about 2 million tonnes of nitrogen per year by transforming phytoplankton to dissolved and particulate forms (Figure 1). Finfish mariculture may contribute a similar quantity. Although

on the global scale this is a minor source to coastal marine ecosystems compared to river export, on regional and local scales it may be important. The spatial allocation of the aquaculture nutrient release were refined, for example with maps published by FAO, and information from Chile and China (Figure 2).

3. A key question to be answered by the working group relates to the coastal environment. To analyze the impact of differences in the type of coastal system on the proliferation of HABs, the working group uses information on the retention within different coastal types (Figure 3) (Laruelle et al., 2009). The information on the primary production in various coastal types as influenced by river export was first analyzed during the Denmark meeting.
4. A further task of the working group is to collect and analyze data on HAB occurrences. Two approaches are followed. Firstly, regional time series of HABs and nutrient loading are collected in different parts of the world, that is, South America, Gulf of Mexico, U.S.A., Gulf of Oman, and Hong Kong. The purpose is to study relationships between nutrient loading and the occurrence of HABs on the basis of detailed spatial and temporal information on the environmental conditions. This is an ongoing activity.
5. Simulations with the POLCOM-ERSEM Global coastal ocean model have been made for NW European shelf & Baltic, Benguela upwelling, Humboldt current, Indonesia and South China seas, Yellow sea and sea of Japan, California Current, Bay of Bengal, Mauritanian upwelling. These simulations are based on Global NEWS data and include 20-year hindcast, 20-year pre-industrial (~1860), and 20-year future climate simulations (~2080-2100). These simulations are currently being evaluated. Furthermore multiple driver scenarios were analyzed as a part of the FP7 MEECE project, with a set of future climate scenarios combining both climate impacts (IPSL A1B) and nutrient loads (derived from the AR4 SRES scenarios). These will be run for the North Sea. Proposed further work includes re-runs for key regions (e.g. China, Bay of Bengal) with nutrient loads including aquaculture.
6. The above regional data will help to guide the second part of this work, that, the analysis of relationships between nutrient loading and HAB occurrences at the global scale. Secondly, the working group has compiled first versions of global maps of occurrences of *Prorocentrum minimum, Noctiluca, Pseudo-nitzschia* and *Karenia*. The collection of such data from literature, reports and other sources to complement these maps will continue through summer 2010. Routines were developed to combine the HAB maps with the nutrient inputs from rivers from the Global NEWS data, the new aquaculture spatial data and the coastal typology. Where needed, supplementary data on environmental conditions have been added. Much work has been devoted to statistical techniques for doing so that can cope with the problem of the absence of observations of "no-occurrence" of HABs. The data have been analyzed and further work is needed in the second half of 2010 where the ERSEM model output will be used (see part II).
7. Various papers from the working group have been published (see list at end of report), are in review, or in preparation, including papers on nutrient release from shellfish and finfish aquaculture, global distribution of red and green *Noctiluca*, population dynamics of red and green *Noctiluca scintillans* and their role in planktonic foodwebs. In addition, numerous conference presentations have been made crediting SCOR/LOICZ 132.

II. GOALS AND ISSUES FOR DISCUSSION FOR THE GREECE MEETING NOVEMBER 2010

The final meeting of the Working Group is planned in Greece in October 2010. Prior to the third meeting, the group will collect more HAB event observations (Europe) from HAEDAT and literature. Furthermore, data from the ERSEM model will be used for the regions of NW Europe, Benguela, Indonesia + SW Asia. Data will be aggregated temporally to seasons and spatially to 0.5 by 0.5 degree grid cells. At that aggregation level, parameter values considered to be drivers of factors in development of HABs will be compared. Nutrient loads for 1860 (pre-industrial, low nutrients) will be compared with current situation (with nutrients) to analyze impact of nutrients and improvement of correlation with observations of HAB events. Further, statistically analysis will be conducted of species distribution with respect to nutrient loading, nutrient forms and nutrient ratios, coastal type, and nutrient loading from marine aquaculture (shellfish, finfish) and impact of aquatic plant production.

In recent decades there has been an increase the fraction of reduced forms of nitrogen inputs to coastal seas. This is due to several processes, such as increasing use of urea fertilizers, increasing ammonia deposition, increasing sewage loads, etc. In addition, the ratios of N to P have changed in many regions according to the Global NEWS data (Seitzinger et al., 2010). The NEWS data will be re-visited to assess the contribution of reduced N forms to total N in river export. Together with the estimates of nutrient release by aquaculture, the group will assess if there is any correlation with observed HABs, and future scenarios will be used to assess further changes as a consequence of economic and societal changes.

Another task prior to the third work group meeting will be to apply the coastal type box model to calculate primary production and retention of nutrients. The group will also assess the possibility to include the impact of aquaculture production.

The major goals for the third work group meeting are to:

- Review model output and further statistically analyze species distribution with respect to nutrient loading, nutrient forms and nutrient ratios, coastal type, and nutrient loading and uptake by marine aquaculture based on the ERSREM model results obtained in the past year. The work group will also discuss possibilities for extrapolation of these findings outside model areas.

Specific issues for discussion include:
- Discuss outline for papers for a journal special issue.
- Updating of the project website; make data available
- Discuss other ways to disseminate the data, for example, through the World Resources Institute.

Finally, it is worth noting that additional funding has been sought to continue the working group activities beyond October 2010. Funds were requested for a supplemental meeting in Chile in May 2010, but this was postponed due to the earthquake.

Papers from the Working Group

Glibert, P.M., J. I. Allen, L. Bouwman, C. Brown, K.J. Flynn, A. Lewitus and C. Madden. 2010. Modeling of HABs and eutrophication: status, advances, challenges. *J. Mar. Systems*. Doi: 10.1016/j.jmarsys.2010.05.004.
Harrison, P., Furuya, K et al. Global distribution of *Noctiluca*.

The working group was also acknowledged in the following papers:

McGillicudy, D.J., Jr., B. de Young, S. Doney, P.M. Glibert, D. Stammer, and F.E. Werner. Models: Tools for synthesis in international oceanographic research programs. *Oceanography*.
Glibert, P.M. Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco Estuary, California. *Reviews in Fisheries Science.*
Overbeek, C.C., Bouwman, A.F., Beusen, A.H.W. and Pawlowski, M., 2010. Past and future nitrogen and phosphorus balances and feed use in global aquaculture: II finfish. Submitted to *Reviews in Fisheries Science*.
Pawlowski, M., Bouwman, A.F., Beusen, A.H.W. and Overbeek, C.C., 2010. Past and future nitrogen and phosphorus balances and feed use in global aquaculture: I shellfish and aquatic plants. Submitted to *Reviews in Fisheries Science*.

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Laruelle, G.G., Dürr, H.H., Slomp, C.P., Van Kempen, C.M. and Meybeck, M. (2009) Nitrogen and phosphorus retention in nearshore coastal environments: a global-scale modeling approach. Manuscript in preparation.
Seitzinger, S.P., Mayorga, E., Bouwman, A.F., Kroeze, C., Beusen, A.H.W., Billen, G., Drecht, G.V., Dumont, E., Fekete, B.M., Garnier, J. and Harrison, J.A. (2010) Global river nutrient export: A scenario analysis of past and future trends. Global Biogeochemical Cycles 23, doi:10.1029/2009GB003587.

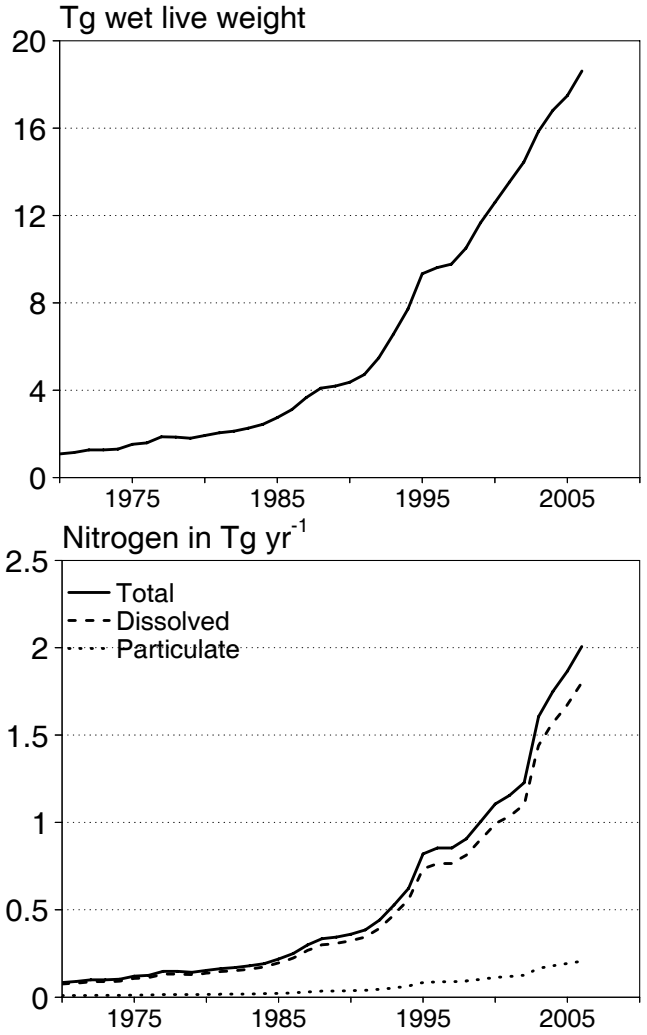

Figure 1. Shellfish production (top) and nitrogen release from shellfish aquacultural systems (bottom) for the period 1970 to 2006. Nitrogen release is based on a simple model; a similar model was developed for finfish.

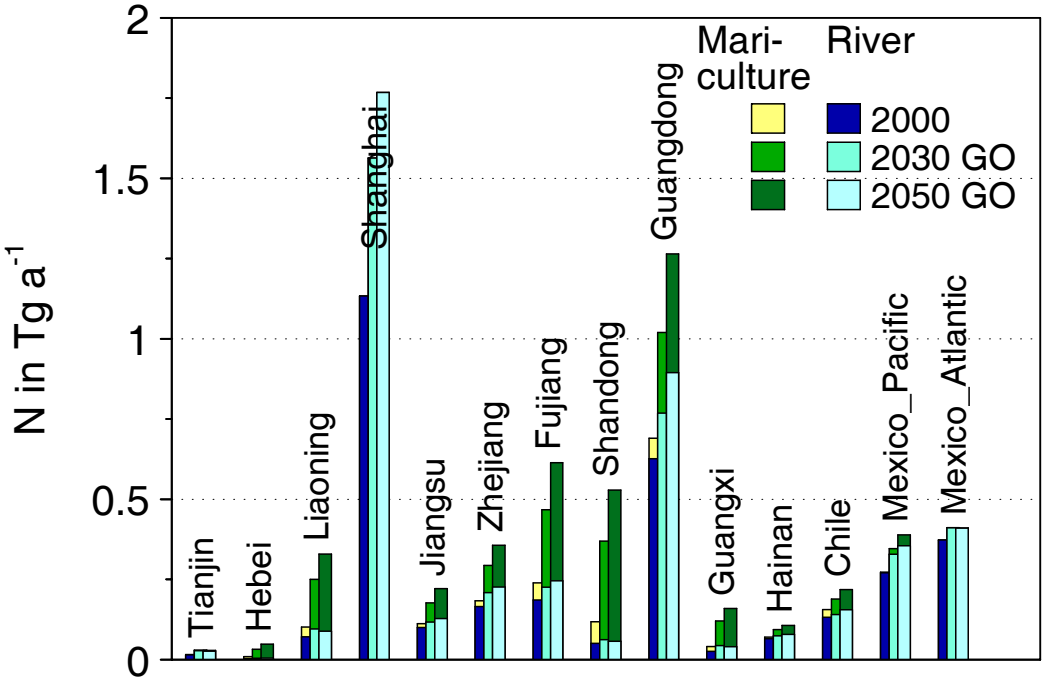

Figure 2. Release of nitrogen from maricultural production and river export in the coastal provinces of China, in Chile and Mexico for 2000 and for 2030 and 2050 according to the Millennium Ecosystem Assessment's Global Orchestration scenario.

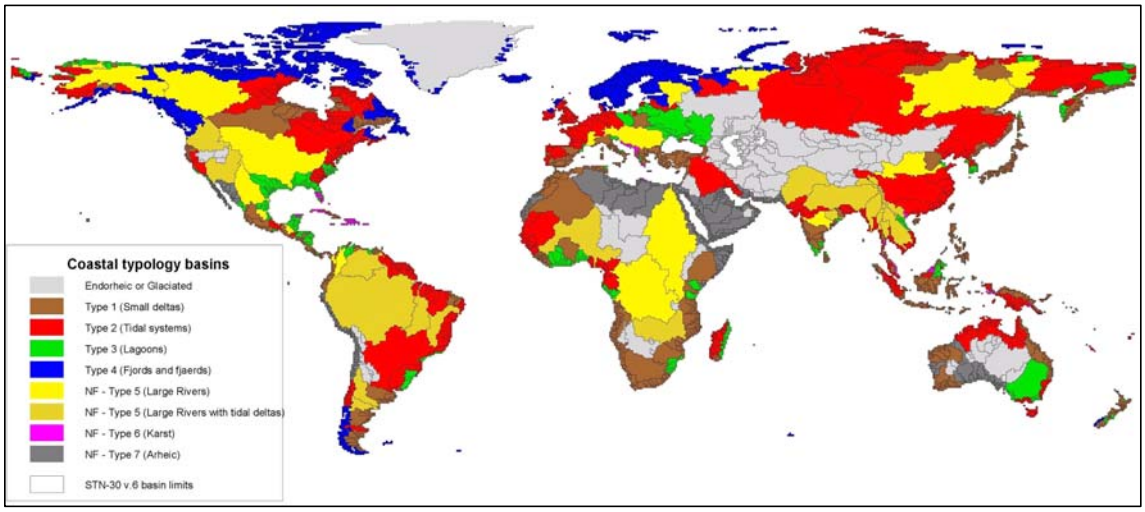

Figure 3. Global coastal types used in SCOR work group 132 (Laruelle et al., 2009). The coastal types and models for nutrient retention within these types are a product of the GINUX project of Utrecht University, the Netherlands.

Annex A

Terms of reference for the working group

1. Integrate existing databases and nutrient loading databases into a comparable GIS format;
2. Advance the development of a GIS coastal typology and its relationship to HABs;
3. Interrogate the above databases for relationships between HAB species, nutrient loadings/forms/ratios and coastal typology and develop broad relationships with specific HAB species;
4. Explore possible changes in HAB occurrences in the future (for example, year 2030) using the relationships developed above and global nutrient export patterns under the Millennium Scenarios;
5. Publish the results in peer-reviewed scientific journals, and develop articles for GEOHAB and LOICZ newsletters as well as other outlets. Papers may cover the global perspective, regional time series and individual case studies.

A large part of the discussions concentrated on the key questions that need to be answered by the working group that cover the issues formulated in the terms of reference and that can be translated in a workable approach. Four key questions evolved from these discussions:

Key Questions

Do relationships exist between HABs and nutrient loading and can we quantify those with respect to:

1. Typology of coastal marine ecosystems (based on physical and biological parameters)?
2. Spatial variation of nutrient loading, forms and ratios?
3. Temporal variation of nutrient loading, forms and ratios?
4. Relative contribution of different nutrient sources including aquaculture to nutrient loading?

Annex B

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Goulven Laurelle, Netherlands

2.2.9 SCOR/IAPSO WG 133: OceanScope
(2008)

Terms of Reference

1. Identify ocean observations and scientific needs with respect to parameters and geographic location
2. Given these needs, identify and prioritize marine routes for sustained ocean observations
3. Classify and identify commercial vessel types suitable for sustained observations
4. Identify available technologies that can enhance vessel capability for ocean observations
5. Identify and prioritize instrument needs to meet *future* mission requirements
6. Identify and develop procedures (hardware and software) to meet communications needs
7. Develop procedures and algorithms for managing data flow, handling, and archival. Address related issues of data ownership (e.g., when routes occur within national Exclusive Economic Zones), data availability and data dissemination. In general, the expectation is that data would be made freely and widely available to all interested users.
8. Address what kind(s) of organizational structure(s) will best serve to initiate, implement, and sustain an integrated international merchant marine-based ocean observation program, linked closely to existing ocean observing systems and programs with access to appropriate and sufficient long-term funding sources (e.g., an "Ocean (or Interior) Space Center")

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Executive Committee Reporter: Missy Feeley

2.2.10 SCOR WG 134: The Microbial Carbon Pump in the Ocean (2008)

Terms of Reference:

- Summarize representative microbial data on biomass, production and diversity of functional groups (AAPB, CFB, Roseobacter, Archaea) and overall microbial communities, as well as DOC data focusing on the context of RDOC dynamics along environmental gradients (productivity/temperature/salinity gradient such as estuarine to oceanic waters); Establish the current state of knowledge about microbial processes that produce RDOC at the expense of DOC, and identify essential scientific questions regarding microbial carbon pump to be addressed in the future;
- Assess the available techniques for quantifying microbial functional groups and demonstrating the bioreactivity of marine DOC, document state-of-the-art techniques and parameters addressing microbial processing of organic carbon, and establish/standardize key protocols for the essential observation/measurements;
- Convene International Workshop(s) and publish a special volume in an internationally recognized peer-reviewed journal, or a protocol book (practical handbook) by a major publisher on measurements of the key parameters related to microbial processing of carbon in the ocean.
- Make recommendations for future research related to the microbial carbon pump in the ocean, toward development of a large-scale interdisciplinary research project.

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Gerhard Herndl (Netherlands)	Sang-jin Kim (Korea)
Gerhard Kattner (Germany)	David Kirchman (USA)
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Executive Committee Reporter: Bjørn Sundby

Annual Report of SCOR WG134
Microbial Carbon Pump in the Ocean

1. Meetings and Academic activities

(A) Meetings held/participated

1) First WG meeting (Oct. 27-30, 2009)

The first meeting of SCOR Working Group (WG) 134 was held in Xiamen, China during October 27-30, 2009. With the theme of "Bridging Biology and Chemistry in Ocean Carbon Sequestration", the meeting was composed of two sessions, the Open Science Meeting and the Closed Workshop.

The meeting was convened by Co-Chairs Prof. Nianzhi Jiao, State Key Lab for Marine Environmental Sciences, Xiamen University, China, and Prof. Farooq Azam, Scripps Oceanography Institution, USA, and joined by 20 experts from 10 countries, including China, USA, Germany, France, Canada, Spain, Netherlands, Denmark, Czech Republic and India. Besides the WG members, more than 50 Chinese scientists and students participated in the Open Science Meeting. Participants benefited much from the cutting-edge presentations related to carbon cycling and its controlling mechanisms.

At the workshop (Oct. 29-30), the panel members had ardent discussions regarding the theme of WG 134 -- microbial carbon pump and related concepts and techniques. Toward the goal of the WG134 --- to identify priority scientific questions and the corresponding techniques, the workshop revisited the terms of reference of the WG134. Relevant scientific questions and techniques were reviewed. One of the concerns was the definition of RDOC (refractory/recalcitrant dissolved organic carbon). Currently, different definitions by different disciplines have been used in the literature, and sometimes are confusing. In marine geochemistry, RDOC is referred to as the old DOC with ^{14}C age of 4000-6000 yr, while in marine ecology and microbial oceanography, RDOC is referred to as the DOC that is resistant to biological utilization. In practice, both definitions are operational, and refer to different materials that exhibit reactivity on different time scales. Bridging the theoretical gap should be one of the missions of WG134. The MCP conceptual framework provides a linkage between the two disciplines.

The meeting reached the consensus that WG134 has the advantage of joint efforts from multiple disciplines; the gaps between microbial ecology and geochemistry are really the topics for the WG to deal with; the WG will work out some ways to put the scientific questions in perspective and lead research in the MCP study. The experts agreed that the MCP is a new proposition which brings into focus multi-disciplinary efforts, and is likely to create a number of new guidelines for the future research directions. It is hypothesized that a context of MCP with related abiotic processes is central for the understanding of carbon cycling and sequestration in the ocean. Despite in-depth discussion and research, a 3-day workshop was too short, and there is much work to do in the future. The panel members plan to write review papers on RDOC- and

MCP-related issues. A microbial subgroup and a geochemical subgroup were set up to facilitate addressing the detailed targets. The meeting started collaborations among individual members, serving to provide opportunities for biological and biogeochemical scientists to work together on some joint projects. More details can be be found at the WG134 website at http://mme.xmu.edu.cn/mcp/eindex.asp

Open Science Meeting

Closed Workshop

2) The cross-disciplinary workshop (Beijing, July 24-26, 2009)
Co-Chairs: N. Jiao, S Xie, X. Chu. Historical evidence for the MCP was discussed among >30 scientists from microbial ecology, geochemistry, and paleobiology.

3) The MCP concept was presented at the AGU Chapman Conference on the Biological Carbon Pump of the Oceans (Brockenhurst, Hampshire, England 1–4 September 2009).

4) Prof. Ron Benner was awarded the Einstein Professorship of the Chinese Academy of Sciences (CAS). In June of 2010, Benner visited three institutes of the CAS in Guangzhou, Qingdao and Beijing to present a lecture entitled, "Bacterial remnants as major components of the global carbon and nitrogen cycles". Prof. Benner had numerous discussions with faculty and students on the role of bacteria in the production of refractory organic matter and the microbial carbon pump.

5) A session on Microbial Roles in Marine Carbon Cycling and Ocean Acidification Impacts was convened by N. Ramaiah, K. Hamasakai and K. Gao during the AOGS 2010 Hyderabad (India) Meeting (July 5-9, 2010). Presentations dealing with microbial roles in mobilising carbon in the oceanic ecosystems suggested that a paradigm shift under ocean acidification is necessary for deciphering the production of dissolved organic carbon/matter (DOC/M) refractory to microbial uptake so that it can reside unaltered in seawater for several thousands of years, and the MCP has to be strengthened globally to not only investigate the chemical characteristics of this refractory DOC/M but also to realise the actual role and importance of marine microbes in ocean acidification as well as climate change researchs.

6) The First International Conference on Marine Science and Earth System (Shanghai, June 27-30, 2010, >500 participants)
N. Jiao was invited to give a plenary lecture on the MCP.

A special session titled "microbes and carbon cycling in the ocean" was convened by N. Jiao, C. Zhang, X. Chu.

7) Gordon Research Conference on Marine Microbes

The Gordon Research Conference held at Tilton School NH (July 4-9) provided another opportunity for the WG members to meet and discuss more details about microbial processes of carbon in the ocean. D. Kirchman (Chair), G. Herndl and I. Obernosterer (speakers), N. Jiao (Discussion leader) and other members attended.

(B) Meeting planned

1) WG134 2nd meeting in Puerto Rico

The 2nd WG134 meeting is decided to be held immediately after the ASLO meeting in Puerto Rico in Feb. 18-20, 2011.

One focus for the meeting will be to consider experimental designs to test the effects of the MCP. For example, we would like to propose a joint effort on *in situ* experiments regarding the effects of the MCP. An ideal place would be the Pacific Warm Pool which can be a scenario of a changing ocean under global warming.

2) AAPB workshop

The workshop (Sept 22-24, Trebon, Czech Republic) is chaired by Michal Koblizek, with the aim to bring together microbiologists, environmental microbiologists, biochemists and biophysicists working on Aerobic Anoxygenic Phototrophic bacteria to exchange their ideas. The workshop also will feature technical practice.

3) IMBC session of "Biotic Carbon Sequestration"

A session of "Biotic Carbon Sequestration" (Jiao-Convener) at the 9th International Marine Biotechnology Conference will be held in Qingdao, October 8-12, 2010.

4) The MCP session at ASLO Aquatic Sciences Meeting February13-19, 2011.

Session title – "Microbial Carbon Pump: A multidisciplinary focus on origins, cycling and storage of DOM in the ocean", Chairs: G. Kattner, N. Jiao, F. Azam and S. Wilhelm

Session description: The majority of dissolved organic matter (DOM) in the ocean has an average age of 4000 to 6000 years. These substances must be extremely resistant against biotic and abiotic degradation and/or almost unusable for microorganisms. DOM, produced via a number of foodweb processes, undergoes multiple transformations to semi-labile and finally to recalcitrant DOM. Some of those transformations are governed by bacterial processes. The specific mechanisms that generate recalcitrant DOM are largely unknown. Moreover, with limited ability to characterize the molecular structures of DOM it is difficult to discern why some is resistant to biotic and abiotic decomposition. The interaction between microbes and the production and removal of recalcitrant DOM requires further information of both microbial function and molecular-level determination of DOM to assess the impact of DOM on global carbon cycles. This session seeks to

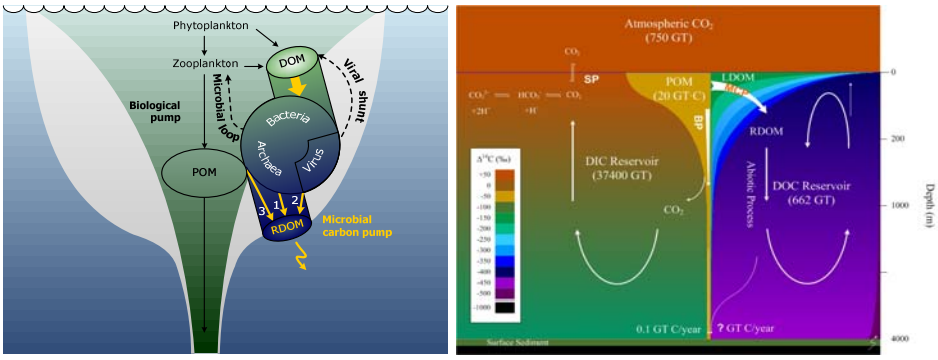
develop a close co-operation between chemists and microbiologists that is indispensible to understand the cycling and storage of DOM.

2. Publications (Papers/Reports)

(A) Published

1) Establishing the MCP conceptual framework –A featured article of *Nature Review Microbiology* 2010 (8).

Jiao, Nianzhi, Gerhard J. Herndl, Dennis A. Hansell, Ronald Benner, Gerhard Kattner, Steven W. Wilhelm, David L. Kirchman, Markus G. Weinbauer, Tingwei Luo, Feng Chen, Farooq Azam, 2010. Microbial production of recalcitrant dissolved organic matter: long-term carbon storage in the global ocean. *NATURE Review Microbiology* 2010 (8):593-599. In this paper, the background, rationale and application of the MCP concept are discussed: representative microbial data on biomass, production and diversity of marine microbial communities in the context of DOM dynamics along environmental gradients, as well as the current state of knowledge about microbial processes that utilize, generate and transform DOM are summarized; essential scientific questions and hypotheses regarding DOC accumulation through the MCP are established. The gaps in our understanding of marine DOC and the microbial community structure in different marine regions regarding bioreactivity are identified, and future research directions are proposed.
This paper is published as a NRM featured article of the issue of August of 2008.



The MCP (left) and major carbon reservoirs in the ocean (right)
(Jiao et al. *NATURE Review Microbiology* 2010 (8):593-599)

2) Science NewsFocus on the MCP

A recent *Science* News Focus article (*SCIENCE* 328:1476-1477, 2010) tells a feature story about the MCP: its origin, rationale, implications, applications, impacts, as well as prospects. In this article. The MCP is considered as "an invisible hand behind the vast carbon reservoir".

3) Marine snow are active sites of microbial remineralization

Bochdansky, A.B., H.M. van Aken, G.J. Herndl, 2010: Role of macroscopic particles in deep-sea oxygen consumption. Proc. Natl. Acad. Sci. USA, 107: 8287-8291. In this paper, non-sinking particles in the meso- and bathypelagic Atlantic have been quantified and related to the oxygen utilization in the layers where the particles are most abundant. A tight inverse cross-correlation between the abundance of these marine snow particles and the oxygen concentration in the surrounding waters was found indicating that marine snow in the deep waters are active sites of remineralization.

(B) To be published

3) Major DOC fractions defined by reactivity

Hansell, D.A., Carlson, C.A., Schlitzer, R. have prepared a manuscript for *Science*. They employ a new, vastly enlarged global ocean data set to produce unprecedented insights on the slow, deep removal of the massive pool of organic matter, and characterize major fractions of exported carbon by removal rates, allowing quantification and localization of global ocean sinks.

4) Characterization of RDOC

The Geochemical Subgroup led by Gerhard Kattner and Stemon Colin are calling for efforts to identify and quantify the sources, sinks, and structural characteristics of RDOC. A coordinated international effort to collect, isolate and characterise deep ocean DOC in the major oceanic basins may offer an insight into why RDOC is so persistent. The chemical characterisation of RDOM has to be improved. A global comparison of deep ocean DOM using a battery of analytical techniques and a comparison of available isolation techniques with detailed chemical characterisation is extremely important. Further work is required to generate a community reference marine standard similar to those currently available from freshwater by the International Humic Substances Society.

3. Research projects/activities

1) A NSFC stratagem project on the MCP (PI Jiao) is on going (2009-2011)
2) A Chinese project on carbon storage in the ocean (RMB 15million) led by Nianzhi Jiao has been launched in 2010
3) A European Science Foundation project on the role of deep water autotrophic prokaryotes in the organic matter synthesis of the deep North Atlantic. led by Gerhard J. Herndl has been launched in 2010.
4) A few scientists from WG134 have got involved in the European Project on Ocean Acidification (May 18 – July 16, 2010).
5) A U.S.-China joint project on functional adaptation of cyanobacteria to the polar oceans regarding its role in carbon cycling in the ocean (Chen, Harvey, Mulholland, Fricke, Jiao) is proposed to the NSF.
6) A cruise to the Pacific Warm Pool as a pilot study on the mechanisms of the MCP will be carried out this October.

2.2.11 SCOR/InterRidge WG 135: Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles

(2008)

Terms of Reference:

- **Synthesize** current knowledge of chemical substrates, mechanisms and rates of chemosynthetic carbon fixation at hydrothermal systems as well as the transfer of phytoplankton-limiting micronutrients from these systems to the open ocean.
- **Integrate** these findings into conceptual models of energy transfer and carbon cycling through hydrothermal systems which would lead to quantification of primary production in view of a future assessment of the contribution of these systems to the global-ocean carbon cycle.
- **Identify critical gaps** in current knowledge and proposing a strategy for future field, laboratory, experimental and/or theoretical studies to bridge these gaps and better constrain the impact of deep-sea hydrothermal systems on ocean carbon cycles.

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Executive Committee Reporter: Missy Feeley

WG 135 – Working Group Report – 13/06/10

Hydrothermal energy transfer and its impact on the ocean carbon cycles

1. First meeting objectives and participants

The first WG 135 Meeting took place in Woods Hole, Massachusetts, USA on 23-24 Nov. 2009. Logistical support was provided for this meeting from InterRidge, which arranged access to all meeting facilities at WHOI. The aim of this first meeting was to discuss the most relevant way to address the WG terms of reference and to clarify the expected outcomes of the WG, while discussing science plans and opportunities arising in partnership with various other initiatives.

WG members present at the meeting were: Nadine Le Bris, Chris German, Wolfgang Bach, Loka Bharathi, Nicole Dubilier, Katrina Edwards, Peter R. Girguis, Xiqiu Han, Louis Legendre, Julie Huber, Stefan Sievert, Andreas Thurnherr, George Luther (teleconference, 24 Nov.), William Seyfried (teleconference, 24 Nov.) .
Excused: Ken Takai, Françoise Gaill, Toshitaka Gamo, Meg Tivey.

Additional participants were: Ed Urban (SCOR, by Skype, 23/11), Jian Lin (InterRidge Chair), Stace Beaulieu (InterRidge Coordinator).

2. Related programmes

After a general introduction of SCOR (E. Urban) and InterRidge (J. Lin), first items on the agenda were to address the links of the WG with current international initiatives.

- The multi-disciplinary input that this WG could provide to **GEOTRACES** (SCOR) though a Chemical Oceanography proposal for a series of submersible dives, as a complement to a planned southern East Pacific Rise GEOTRACES transects was the first such example to be mentioned.
- Potential for complementary initiatives was also identified with a number of **IODP** projects planned in partnership with the InterRidge *Deep Earth Sampling* WG and/or arising from a recent 'Dark Energy' (NSF-NASA) workshop, focussing on the deep (sub-seafloor) biosphere. In a related development, the Dark Energy Biosphere Institute (DEBI) has recently been funded by NSF to resolve the extent, function, dynamics, and implications for the sub-seafloor biosphere. Key themes for the forthcoming North Pond (Mid-Atlantic Ridge flank) IODP drilling project include: functions and rates of global biogeochemical processes; the extent of life in the deep biosphere; limits to the existence of life; and evolution and survival in the deep biosphere – all of which are directly relevant to the scope of this WG.
- A possible connection with the SCOR/IGBP **IMBER** programme was also discussed. To date, only pelagic ecosystems are being considered within the scope of IMBER, with

increasing attention paid toward processes at greater depths below the air-sea interface, but not to benthic systems. Links will mostly be possible, therefore, through considerations of nutrient and organic carbon export from hydrothermal systems to the overlying water column.

3. Discussion on WG 135 Terms of Reference

Hydrothermal systems have been studied for 35 years now, but the issue of their impact on global-scale ocean biogeochemistry remains to be adequately addressed. Rather, vent ecosystems are often described as being largely independent of the rest of the biosphere, but the extent to which they are inter-connected with the photosynthetic world still needs to be assessed. One way of considering this question is *to consider the service that is provided by these systems to the ocean as a whole*. For example: if we removed hydrothermal systems from Earth, what would be the impact on ocean ecosystems and on carbon sequestration by the ocean?

How much carbon is exported out of vents (inorganic and organic carbon, including methane) remains largely unknown. Examples of relevant questions to this WG are: what do we know about the global export flux of methane from ridge axes? How much microbial biomass is trapped in the subseafloor, and how do the microbes that live *within* the crust affect the carbon balance to the ocean? Can we estimate the fraction and nature of organic carbon exported from vent sites to oceanic ecosystems? Beyond carbon, what other elements are likely to have a significant impact on ocean biogeochemistry? Recent estimates have suggested that 10-25% of all dissolved Fe in the deep ocean may be hydrothermally sourced, but how much impact do vents have on other trace metals that can also act as micronutrients – e.g. nickel, which is known to be important in enzymes? Conversely, we can also address the link between hydrothermal biogeochemical systems and the photosynthetic world by asking questions that consider the reverse order. For example: how much of the life at vents depends on a well-oxygenated ocean to function?

Our objective is to engage the broader community in our work and, concurrently, to help shape the future direction of submarine hydrothermal research. Key goals identified include:

1. To constrain the micronutrient hydrothermal fluxes and their influence on ocean productivity.
2. To assess the productivity of seafloor and subseafloor vent ecosystems and their dependence on oceanic processes
3. To estimate the extent of new DOC and POC production and export from seafloor hydrothermal systems and how these fluxes may influence deep water ecosystems.

One of the main difficulties in the above concerns how we calculate carbon fixation rates, locally, and then how we should extrapolate those values to apply them at the global scale. We have extant data in hand, although they are patchy. Studies are available: on microbial carbon fixation rates (mostly from the 1980s before microbial studies moved toward assessing diversity); macrobiological biomass production from symbiotic organisms; complexity in terms of geochemical composition; and energy budgets for released hydrothermal fluids, which may

stimulate different microbiological processes. To identify what we still don't know is likely to prove as important as establishing what we *do* already know, if we are to address our terms of reference. One possible approach would be to start with inverse modelling to identify which key *rates* are currently unknown. From this, it will be possible to plan the necessary measurements to constrain and/or estimate those rates.

Both axial and off-axis hydrothermal systems are hydrologically connected to the ocean system. Consequently, we need to identify the important parameters that need to be measured at these quite different vent systems if we are really to achieve an improved understanding of the hydrothermal fluxes that obtain across numerous different length scales. We also recognize the need to incorporate the concept of "patchiness" into our considerations and not simply generate global estimates, to ensure that we assess the role of hydrothermal circulation on ocean carbon budgets at different length scales. Global impacts usually don't take place 'on average' but through localized interactions. For example, despite comprising an aerially and volumetrically insignificant component of the deep seafloor, seamounts exert a huge ecological influence as local hotspots of reproduction and diversity. Similarly, interactions with deep sea hydrothermal systems may result in bursts of productivity in deep, oligotrophic waters and, consequently, impart a profound impact on ocean carbon cycling.

New technologies – both to study large-scale processes and in the context of observatory science – are offering novel opportunities with which to further constrain geochemical and biological rates and fluxes. For example, CORK observatories in drilled holes have been used over the past 4 years to provide better access to biomass and microbial activity in the deep hard rock biosphere than is achieved from the act of drilling. Indeed, it remains difficult to recover drill-core samples of suitable quality for microbiology (or fluid chemistry) studies. A similar problem is encountered with most "snap-shot" plume studies. Measurements from one-off investigations may yield concentrations but only time-series plume investigations can be expected to yield information on hydrothermal *fluxes*.

One interesting point that was discussed concerns the extent to which new technology may help us to assess the "patchiness" of hydrothermal-ocean interactions in the future. Just as satellite surveys already allow us to capture global distributions of parameters in the surface ocean, next-generation AUVs such as the 6000km-range and 6000m-rated AUTOSUB already under development in the UK, when equipped with the appropriate sensors, should allow us to design new deep-ocean observation strategies, in the next 10-20 years, that are an order of magnitude more complex than anything we have been able to conduct at the deep seafloor.

4. Outcomes of the Working Group

4.1. Agenda

Some important dates over the proposed lifetime of SCOR WG135 have been identified, and these were used to inform our decision on the location and time of our second meeting.

2010
Main WG activities:
• **Submission of position papers** (see later).
Relevant and related activities:
• June 2010 Goldschmidt conference (Theme 5: Evolution of Oceanic Crust and its Hydrothermal Systems led by WG members Bill Seyfried and Wolfgang Bach; session in Theme 15 Geomicrobiology of Mid-Ocean Ridge Systems led by Brandy Toner)
• IR Long-Range Exploration WG community workshop in June 2010.

2011
Main WG activities:
• **Second SCOR WG135 Meeting.**
Xiqiu Han has offered to host the WG for its 2nd meeting at the 2nd Institute for Oceanography, in Hangzhou, China. The proposed data for the meeting is late April 2011. We might be able to anticipate some travel support from her institution (for local costs within China for board and lodging) and food.
• **Submission of proposals to support a community-wide workshop** (e.g. to InterRidge, ESF, AGU, other).
Relevant and related activities:
• InterRidge Mantle Imaging WG community workshop.
• Goldschmidt Conference special session (Prague, June)

2012
Main WG activities:
• **Community-wide workshop** (to be held in Europe, in May/June)

Relevant and related activities:
• Completion of hydrothermal GEOTRACES cruise to the Southern East Pacific Rise

4.2. **Workshop date and location**
The community-wide workshop for this WG will be held in Europe in May/June 2012. To sustain momentum, we will also propose related special sessions at one or more major international meetings in the interim (e.g. AGU, EGU, Goldshcmidt and and Western Pacific Geophysics meetings).

In addition to SCOR, we will seek further support from InterRidge and additional workshop funding from ESF, NSF and other national / governmental research agencies – e.g. the U. Bergen Geobiology Institute in Norway, the Sloan Foundation's Deep Carbon program, NASA's Astrobiology Institute and CNRS.

4.3. Position papers
Consensus was developed that two review papers should be drafted, together with a shorter paper that will capture key concepts and present them in an accessible form for a broad ocean science community, in advance of – and to set the scene for - the international community workshop in 2012. The two review papers will each start at the small length scale of a seafloor

vent scale and progressively enlarge their scope and scale to answer our key questions (as summarized in Figure 1). The main goal of these papers will be to provide a basis from which to explain why we think these systems are important to study, to the broader oceanographic community, and to help establish what new approaches are needed to progress this field. Starting with the best-studied hydrothermal sites known, our framework will be to summarize existing knowledge on these three questions:

1. What are the important processes active in the system?
2. What missing information do we need to know about mechanisms and rates?
3. Where are the gaps and what new measurements are needed?

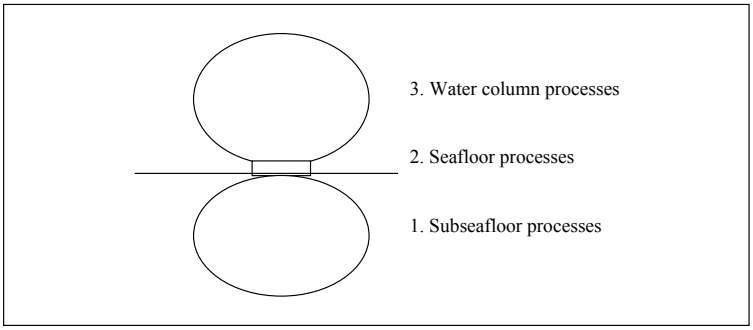
4. 

Figure 1: Scheme of the approach developed for the two position papers. (2. will be synthesized in a first large review, and 1 and 3 together in a second one).

The 1st paper will focus on seafloor hydrothermal systems themselves. An integrated understanding of the processes that support these unique ecosystems should be highlighted, including considerations on both spatial and temporal scales, in as detail much as possible, and on the *rates* that control the magnitude and timing of input/output fluxes for nutrients and carbon between ocean and crustal "reservoirs". Focus here will be on the extent of *inorganic* carbon fixation, as well as on the recycling and export of *organic* carbon. This paper will also need to acknowledge the importance of patchiness/spatial discontinuity, from both an ecological and biogeochemical perspective, that will then be considered in more detail in the second-tranche papers. For example, differences between diffuse versus focused flow systems and the differences imparted by changes in axial ridge topography will need to be addressed. Stefan Sievert, Julie Huber, Nadine Le Bris, and Pete Girguis will take the lead on this paper that will cover linkages between microbes, macrofauna and geochemistry and including tentative conceptual model.

The second review paper – led by Katrina Edwards, Chris German, and Wolfgang Bach –will consider the interaction with the water column and with the subseafloor. There are currently two review papers just published or in preparation partly covering this scope: Schrenk, Edwards and Huber are co-authors on a paper defining sub-seafloor provinces, subdivided into biomes, while a new review (Edwards et al), is focusing on dark ecosystems in the marine realm, to describe the pelagic regime from the base of the photic zone to the deep seafloor in terms of what we know microbiologically. Because these reviews are mostly directed toward microbiologists, we consider that a parallel paper for chemical processes at large, including

chemical fluxes in environmental systems, would provide a valuable and timely complement. For example, recent work on ocean carbon budgets have focussed upon chemical reactions for photosynthesis and breakdown (decomposition) of organic matter to CO_2. By contrast, this paper would bring a fundamental understanding to the attention of a wider community on the imbalance that is created through the autotrophic production of organic carbon in chemosynthetic systems with oxygen:

$$\text{Reduced metal/mineral} + O_2 + CO_2 \Rightarrow \text{organic C.}$$

Possible journals for the two longer review papers we propose include *Geobiology* (K. Edwards is on the editorial board), *Deep Sea Research*, GCA, MEPS, L&O, Annual Review and *Journal of Marine Systems* (L. Legendre is on the editorial board).

For the short, high-profile paper to be published first it is proposed that a journal such as *Nature*, *Science* or *PNAS* be approached to attract the broadest possible readership.

5.Working Group composition: complementary expertises needed

• The need to entrain someone from the JGOFS-type community to help with the large-scale review paper was raised. **Philip Boyd** from New Zealand was identified as one potentially ideal candidate because (i) he is well known for his expertise in open ocean iron fertilization experiments and in interests in JGOFS-like global-ocean scale C-cycling and (ii) he would provide the input/WG membership from the Southern Hemisphere that had been recommended previously but which the co-chairs had struggled to address previously. A key question that requires SCOR input is whether we could invite Boyd as an additional FULL member of the WG, or just as an associated member.

• In addition to Boyd, it was agreed that we should expand our intellectual "gene pool" by inviting three further experts to join WG 135 as *Associate* Members**:**
Tom McCollom (University of Colorado) for thermodynamics, geochemical modelling.
Thorsten Dittmar (Max Planck Research Group for Marine Geochemistry at the Carl von Ossietzky University in Oldenburg, Germany) for organic geochemistry.
Bob Lowell (Virginia Institute for Marine Sciences) for modelling of heat fluxes.

2.2.12 WG 136: Climatic Importance of the Greater Agulhas System (with WCRP and IAPSO) (2009)

Terms of Reference:

- Facilitate collaboration between existing and planned (observational and modeling) studies in the greater Agulhas Current system, such that we minimize the gaps in the research, maximize the scientific outcome, and encourage estimates on the robustness of key findings (e.g. multiple model ensembles).
- Write a review paper (for publication in a peer-reviewed journal) that highlights the importance of the greater Agulhas system in terms of global climate, reviewing the current levels of both understanding and uncertainty as to how changes in the system come about, how they effect climate, and vice versa.
- Identify key components of the circulation which deserve further study through physical/palaeo observations and/or models, some of which may act as indices/proxies (through sustained observation) that can help describe the state of the Agulhas system on decadal to climate time scales. Communicate these findings to regional and international strategic planning committees, such as CLIVAR, GOOS, GEOSS, GO-SHIP etc.
- Write a proposal for, and organize, a Chapman Conference on the "Climatic Importance of the Greater Agulhas System", to be held in 2012.

Co-chairs:

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Other Full Members Meghan Cronin (USA) Will de Ruijter (Netherlands) Juliet Hermes (South Africa) Johann Lutjeharms (South Africa) Graham Quartly (UK) Tomoki Tozuka (Japan) Rainer Zahn (Spain)	**Associate Members** Shekeela Baker-Yeboah (USA) Jeff Book (USA) Tom Bornman (South Africa) Paolo Cipollini (UK) Ian Hall (UK) Alan Meyer (South Africa) Wonsun Park (Germany) Frank Peeters (Netherlands) Pierrick Penven (France) Herman Ridderinkhof (Netherlands) Jens Zinke (Netherlands)

Executive Committee Reporter: John Compton

2-106

Annual Report 2009/2010: SCOR WG 136

Working Group On the Climatic Importance of the Greater Agulhas System
Lisa Beal and Arne Biastoch, co-Chairs

1. 2010 WG Meeting

SCOR Working Group 136 (WG136) held its first meeting in February 2010 over the weekend before the Ocean Sciences conference in Portland, Oregon. There were eight of ten full members present (Johann Lutjeharms and David Obura unable to attend), plus three associate members and twelve guests. Ed Urban of the SCOR secretariat also attended the meeting. A full list of attendees can be found at the end of this report.

The agenda was formulated around the WG136 Terms of Reference:

(1) To facilitate collaborations between existing and planned studies of the region.
(2) Write a review paper that discusses both current levels of understanding and uncertainty as to how changes in the Agulhas system come about, how they affect regional and global climate, and vice versa.
(3) Identify key components of the region that deserve further study and/or sustained observations.
(4) Organise a Chapman Conference with participation of the African science community.

A further goal of the WG is to contribute to capacity building in East African countries which border the Great Agulhas System.

1.1 Reports and Discussions on Current and Future Activities (TORs 1 and 3)

Biastoch summarised current activities of the region known and/or conducted by WG members. These included: Mozambique moorings (LOCO), East Madagascar Current moorings (to be deployed October 2010), Agulhas Current moorings (ACT), a repeat hydrographic line from Cape Town to Antarctica (GoodHope), large marine ecosystem program (ASCLME), African Ceolocanth Program (ACEP), coastal observations maintained by SAEON (South African Environmental Observation Network), collection of paleo data (GATEWAYS), and idealized, regional, high-resolution, and coupled model analyses.

Other ongoing or upcoming projects were presented:

- Goni - NOAA high-density XBT lines (Australia-Seychelles-Durban, Cape Town-New York, Cape Town-Buenos Aires, all 4X per year), and proposed PIES between Cape Town and Antarctica (currently two, but SAMOC group planning more).

- Cronin - A new surface flux mooring (ARC), essentially the first program borne of discussions and collaborations across our WG, will be deployed in the Agulhas Return Current in fall 2010, during the next ASCLME cruise.
- Book - a planned seismic survey to quantify mixing from mesoscale stirring in strong frontal regions (no ship time yet).
- Zahn - New drilling site on southern flank of Agulhas Bank (5Myr) and mouths of Limpopo and Zambezi.
- duTrieux - planning stages for coastal radar and glider observations at 23 S in Mozambique Channel.
- Bornman - next ASCLME cruise in Natal Bight and over Agulhas Bank. **ASCLME will repeat ACT line and deploy Cronin's mooring (collaboration/cooperation borne of our WG)**. Need to develop a 5-year plan to continue cruises/moorings beyond 2010. ASLME/NOAA to sign MoU.
- Quartly - AltiKa to be launched on Envisat track, should be better near coasts. Design EMC moorings along ground track?

Various methods for long-term monitoring were discussed - such as leveraging satellite altimeter data and using underwater cables. Monitoring of leakage was recognised as logistically very challenging. The SAMOC group is proposing CPIES, but Byrne tried this in ASTTEX and no evidence of success. Very complex eddying regime.

1.2 Planning a Review Paper (TOR 2)

First, we had an open discussion, with guests, about what a Review paper should include - what have been the most important advances in Agulhas research over the last ten years? Should we include biophysical aspects, such as the role of the Agulhas in ecosystems? And regional climate effects? Should we highlight also what we don't know - future directions? It was agreed that the most important advances have been those linking the Agulhas to climate variability and AMOC. However, there is still much uncertainty and speculation in these links. More studies are needed.

In the final session of the day, WG members conducted a closed session to set out solid steps towards writing the Review Paper. It was agreed that Beal and Biastoch would be lead authors and that the review would be short, highlighting topical advances rather than a comprehensive literature review. Beal will spend a month in Utrecht to collaborate closely with de Ruijter, who wrote the last review. Members were asked to contribute a list of recent papers and comments in their own field, as follows: Biastoch - impact on AMOC, Cronin (with Reason and Rouault) - Atmosphere-Ocean, Quartly (with Penven) - Biophysics, Tozuka - Climate/oceanic teleconnections, Zahn (with Hall) - paleo observations, Beal and de Ruijter - physics.

A letter proposing a review paper in *Science* will be led by Biastoch. If *Science* is not interested, a similar proposal will be made to *Nature*.

2-108

1.3 Planning the 2011 WG Meeting

WG members discussed plans for the next meeting. It was agreed that we want a week-long meeting (possibly longer) in an East African country where local scientists can participate; possibly in conjunction with a local conference (ASCLME, WIOMSA or similar). Discussions led us to the idea that the key to capacity building is threefold: ongoing contact (establish contact now and maintain through Chapman Conference), building collaborations between local and international scientists, and local institutional buy-in. Hermes will lead the organisation of the next WG meeting, with help from a scientist at an East African institution. We are currently seeking a tenth WG member, to replace Obura who stepped down, who will be this local contact. Additional funding will be necessary to hold a long, open meeting. To this end, Book will lead an ONR proposal for a capacity building workshop which, if successful, would also fund some travel for African scientists. **Also, we ask SCOR to sponsor attendance of African scientists at the meeting.** We anticipate needing fifteen to twenty travel grants, worth $1,000 each. There is more about the planning for this next meeting below.

1.4 Adding Associate Members

In recognition of their enthusiasm and importance to our goals, Book and Bornman were asked to become Associate Members of our WG. Book will help lead an ONR proposal for a capacity building workshop as part of our next WG meeting. Bornman is coordinating ASCLME cruises, which will deploy Cronin's mooring and hopefully re-occupy the ACT hydrographic line.

1.5 Meeting Attendees

Participating WG members (Full and Associate)
Lisa Beal lbeal@rsmas.miami.edu
Arne Biastoch abiastoch@ifm-geomar.de
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Jenny Ulgren (jenny.ullgren@nioz.nl) (Feb 21 only)

2. EOS Article

A Meeting Report was written for EOS, to advertise our WG and its TORs to the wider community and solicit interest and involvement. It appeared in *EOS*, vol. 91, no. 18, 4 May 2010. Two research groups working on Agulhas-related science contacted us following the article.

Eos, Vol. 91, No. 18, 4 May 2010

MEETING

Improving Understanding of the Agulhas Current and Its Global Climate Impacts

Working Group on the Climatic Importance of the Greater Agulhas System; Portland, Oregon, 20–21 February 2010

PAGE 163

The first meeting of the new Scientific Committee on Oceanic Research (SCOR) Working Group 136 was held to discuss recent developments in understanding the greater Agulhas Current system and future research directions. The overarching goal of the working group is to improve understanding and awareness of the regional and global climate impacts of the Agulhas Current, a major western boundary current that flows along the east coast of Africa, and its interocean leakage.

In addition to studying modern circulation, the working group is motivated by recent paleodata that suggest that through the currents' southern influence on the Atlantic meridional overturning circulation (AMOC), changes in the leakage of warm and salty Agulhas waters into the Atlantic may have triggered the end of ice ages. In terms of global climate, this arguably puts the importance of the greater Agulhas system on a par with Heinrich (land-ice release) events and high-latitude deepwater formation.

Recent studies discussed at the meeting suggest that Agulhas leakage is increasing as a result of global warming, with the potential to strengthen the AMOC. This is a profound finding because it could represent a positive feedback on Northern Hemisphere climate change, in contrast to Greenland ice sheet melting, which represents a negative feedback (through weakening of the AMOC). Working group members noted that although the relative strengths of these feedbacks are unknown, these findings suggest that the Agulhas deserves much greater attention from the scientific community.

During the meeting, the working group began fulfilling its first three terms of reference. The first term of reference is to facilitate collaborations between existing and planned studies of the region. Several current observational programs in particular were identified that would benefit from improved coordination across individual disciplines. The second term is to write a review paper that discusses current levels of both understanding and uncertainty as to how changes in the Agulhas system come about, how they affect regional and global climate, and vice versa. The main foci of the planned review paper that shall be communicated to a wider community were discussed at the meeting. The third term is to identify key components of the circulation that deserve further study and/or sustained monitoring; this was also discussed at the meeting.

Over the next 3 years, the working group will meet twice more, next year in East Africa. With help from SCOR's Committee on Capacity Building, the group will look for ways to help build scientific capacity in East African nations, such as Mozambique, Tanzania, and Kenya. More resources in these nations will greatly increase the feasibility of sustained observations over the region in the future. The working group's final term of reference is to plan to hold in 2012 an AGU Chapman Conference, with full participation of the African science community, on the climatic importance of the greater Agulhas Current system.

Anyone interested in the greater Agulhas Current system, or in the goals of the working group, is encouraged to contact the authors of this report. Working Group 136 is cosponsored by SCOR, World Climate Research Programme (WCRP), International Association for the Physical Sciences of the Ocean (IAPSO), and International Marine Global Change Studies (IMAGES). For information about Working Group 136, its full terms of reference, and a list of members, see http://www.scor-int.org/Working_Groups/wg136.htm.

—LISA BEAL, Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Fla.; E-mail: lbeal@rsmas.miami.edu; and ARNE BIASTOCH, Leibniz Institute of Marine Sciences at University of Kiel (IFM-GEOMAR), Kiel, Germany

3. Review Paper

Our proposal for a Review article sparked interest from *Nature*, who have asked for a detailed synopsis of the Article, before they consider commissioning the piece. Recent references with short comments/summaries have been collected from WG members, as outlined during our February meeting. Currently Beal is in Utrecht working with de Ruijter and Biastoch for the month of June on this synopsis, which will be submitted shortly, and also on the review itself.

4. Next WG Meeting

Hermes is leading the organisation of our next WG meeting, which will be held in an East African country. It was hoped that David Obura could help in this endeavour, but he is too busy to contribute and has stepped down. Hence, we are currently seeking a replacement WG member from an East African institution (with the help of ASCLME) who can help host our meeting. Book will lead the development of a proposal to ONR to fund the capacity building elements of the meeting and also provide travel grants for African scientists to attend. **In addition, we are asking SCOR for help with travel grants - we anticipate needing about twenty grants of $1,000 each in all.**

Hermes and Beal are in communication via email and Skype discussing the meeting and, in particular, the format of the capacity building activities. Although the location and plans are not finalised, we have a rough outline as follows:

(1) A science meeting (2 days?) - i.e. presentations by both East African scientists and SCOR scientists of their ongoing work related to the Greater Agulhas system.
(2) A capacity building workshop (how long?)- i.e. training local scientists how/where to find data/information on the Web, (both global datasets and SCOR members project websites), how to share their own data (data repositories, formats, and timeliness), and how to access and use model output (e.g. local ROMS configuration of Penven, and Biastoch's global simulations with regional nesting).
(3) A SCOR WG meeting (2 days?)- i.e. one day open to all, to invite ideas from the East African community in relation to our TORs, plus one day with members only to discuss specific progress and future plans for TORs and products.

Through the summer we will continue to refine these ideas, plus find a 10th WG member and a host institution. At the beginning of August, Hermes will attend a SCOR conference on capacity building in ocean sciences in Germany that will greatly benefit our planning.

2.2.13 WG 137: Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation

(2009)

Terms of Reference:

- Identify existing long time series of phytoplankton data in coastal oceans around the world
- Facilitate migration of individual data sets to a permanent and secure electronic archive (Requirements for development of a fully-stocked phytoplankton data-base greatly exceed the resources of this WG. However, we expect to produce a small working proto-type, based on the existing archive (to be identified) to demonstrate the value of sharing data through an international database.)
- Develop the methodology for global comparisons for within-region and within-time period data summarization (e.g. spatial, seasonal and annual averaging, summation within taxonomic and functional group categories). The goal is to clarify what level of detail provides the optimal tradeoff (i.e. information gain vs. processing effort).
- Based on the above, develop priorities and recommendations for future monitoring efforts and for more detailed re-analysis of existing data sets.
- We will carry out a global comparison of phytoplankton time series using (in parallel) a diverse suite of numerical methods. We will examine:
    - Synchronies in timing of major fluctuations, of whatever form.
    - Correlation structure (scale and spatial pattern) for particular modes of phytoplankton variability (e.g. changes in total biomass, species composition shifts, among different geographic distribution).
    - Amplitude of variability, both for total biomass and for individual dominant species, and a comparison to the amplitude of population fluctuations.
    - Likely causal mechanisms and consequences for the phytoplankton variability, based on spatial and temporal coherence with water quality time series.
- Through comparative analysis, we will address the 3 guiding questions.

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Other Full Members	**Associate Members**
Susan I. Blackburn (Australia)	Borgne, Robert Le (New Caledonia)
Jacob Carstensen (Denmark)	Elgin, Perry (USA)
James E. Cloern (USA)	Jassby, Alan (USA)
Paul J. Harrison (China-Beijing)	Kuparinen, Jorma (Finland)
Ruixiang Li (China-Beijing)	Leppänen, Juha-Markku (Finland)
McQuatters-Gollop, Abigail (UK)	Malone, Thomas (USA)

Todd O'Brien (USA) Clarisse Odebrecht (Brazil) N. Ramaiah (India) Katja Philippart (The Netherlands) Adriana Zingone (Italy)	Moncheva, Snejana P. (Bulgaria) Morán, Xosé Anxelu G.(Spain) Picher, Grant (South Africa) Smayda, Theodore J. (USA) Wiltshire, Karen (Germany) Yoo, Sinjae (South Korea) Zhu, Mingyuan (China-Beijing)

Executive Committee Reporter: Jorma Kuparinen

SCOR WG 137:
Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations

Annual Report 2010

Kedong Yin and Hans W. Paerl

June 15 2010

Background

The proposal for SCOR WG 137 was reviewed independently by SCOR national committees and collectively at the 2009 SCOR Executive Committee Meeting, 20-22 October 2009, in Beijing, China. The Committee agreed that the proposal was well prepared and provides a timely, technically feasible, and extremely valuable next step to understand commonalities and contrasts with regard to ecological responses to natural and human-induced changes of coastal phytoplankton. The 2009 SCOR Executive Committee Meeting agreed to support the proposal funding with the following modifications expressed by the meeting participants.

Proposal Revision

There are three modifications: 1) membership, 2) data sets and 3) oceanographic data.

We have revised the proposal accordingly and the revision is summarized as follows.

1) Membership

New full members include:

Ruixiang Li, First Institute of Oceanography, SOA, China (self funded)
Todd O' Brien, NOAA, USA (self funded)

New associate members include:

Jassby, Alan	University of California at Davis, USA	adjassby@ucdavis.edu
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	Camín de L'Arbeyal, s/n 33212 Xixón , Spain	
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Zhu, Mingyuan**	First Institute of Oceanography, State Oceanic Administration, China	zhumingyuan@fio.org.cn

A copy of the revised proposal is attached (Appendix 1)

2) Data sets

We have included Karen Wiltshire who will work on Helgoland phytoplankton time series data set and Juha-Markku Leppänen who will work on the Finnish Baltic Sea data set.

3) Oceanographic data

We have included Todd O'Brien (WG125 member) as a full member who agrees to provide data access center for WG members.

Activities

1) Revised WG proposal

2) The first meeting planning
The first meeting will be held in Hangzhou, China during the week of October 18, 2010.

3) Jacob Carstensen applied for funding for a data synthesis workshop from the Danish Agency for Science, Technology and Innovation under the "Bilateral Network Activities" scheme in connection with SCOR WG137, and was successful. This workshop is being held in Roskilde, Denmark, on the heels of the EUTRO 2010 Symposium, to be held in Copenhagen 15-18 June 2010. The WG 137 member participants are Jacob Carstensen, Jim Cloern, Hans Paerl, Paul Harrison and Kedong Yin. We will have additional European attendees at this workshop to provide perspectives on data/statistical analyses and modeling. We are planning another smaller workshop in August at the University of North Carolina's Institute of Marine Sciences, Morehead City, NC (USA), and an October meeting in Hangzhou, China.

4) The document "WG137 Data and Policies" has been drafted and distributed among all members. A copy of this document is attached:

Appendix 1. SCOR 137 Working Group Revised Proposal.

A Revised Proposal for SCOR WG 137: Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations

1. Introduction

Background & Rationale

Marine ecosystems are changing rapidly in response to natural processes, human activities, and climate change. These drivers of change have become the subject of an increasingly intense focus from both research and management perspectives. There are important scientific questions that need to be addressed with regard to natural vs human-induced changes including: 1) the qualitative characters of the ecosystem responses ("what changes?"), 2) their amplitudes ("by how much?"), and 3) their timing and spatial and temporal scales ("when and where are rates of change most profound?"). Phytoplankton are excellent indicators of marine ecosystem change. They are ecologically and biogeochemically important and relevant indicators, since they conduct a large share of system-scale primary production and hence C cycling and they are highly sensitive to a suite of environmental stressors. There is much accumulated evidence that diverse ocean regions undergo strong and sometimes abrupt changes in phytoplankton composition, and productivity at roughly decadal intervals (i.e. regime shifts). This variability is associated with corresponding changes in atmospheric, hydrologic, chemical, and higher trophic-level biological processes and state variables. However, our understanding of global change is incomplete because we have not adequately explored, inventoried, nor compared available observational data. Nor do we know how to anticipate the timing and direction of the next major shifts.

The understanding of climate change vs anthropogenic influence in coastal ecosystems is important in sustainable management of coasts. A recent example of a climate change-induced shift in biological communities was reported by Cloern et al. (2007) for San Francisco Bay. The abrupt change in the biological communities was first detected as increasing phytoplankton biomass and the occurrences of new seasonal blooms that began in 1999, overriding the influence of changes in the input of nutrients. There were coincidental higher level biotic changes, including sharp declines in the abundance of bivalve molluscs, the key phytoplankton consumers in this estuary, and record high abundances of several bivalve predators: Bay shrimp, English sole, and Dungeness crab. The phytoplankton increase is consistent with a trophic cascade resulting from heightened predation on bivalves and suppression of their filtration control on phytoplankton growth. These community changes in San Francisco Bay across three trophic levels followed a state change in the California Current System in the form of sudden

increased upwelling intensity, amplified primary production, and strengthened southerly water flows. These diagnostic features of the East Pacific ‘‘cold phase’’ led to strong recruitment and immigration of juvenile flatfish and crustaceans into estuaries where they feed and develop. This study utilized three decades of observations to reveal a previously unrecognized mechanism of ocean–estuary connectivity. This shows that interdecadal oceanic regime shifts can propagate into estuaries and coastal waters, altering their community structure and efficiency of transforming land-derived nutrients into algal biomass.

In October 2007, nearly 100 phytoplankton ecologists gathered in Rovinj, Croatia and attended the AGU Chapman Conference: “Long Time-Series Observations in Coastal Ecosystems: Comparative Analyses of Phytoplankton Dynamics on Regional to Global Scales” (http://www.agu.org/meetings/chapman). They initiated an analysis of phytoplankton changes in many different coastal marine ecosystems around the world, but the comparison and synthesis of the differences between those ecosystems are a huge task, it could not be completed during the 5 day conference and therefore a smaller working group that works over a longer period, is needed to continue the analysis of these valuable data sets not only in science, but also for management needs.

Proposed SCOR Working Group

We are proposing to form a SCOR Working Group to focus on coastal ecosystems (estuaries, fjords, bays, sounds, open waters of the continental shelf, etc.) where perturbations from terrestrial, atmospheric, oceanic sources and human activities converge to cause changes that ramify across local and global scales. Human pressure on coastal regions and continental margins is increasing with expanding urbanization and the conflicting demands of tourism, agriculture and aquaculture, water diversions, wind parks and other developments. Our proposal to develop a SCOR Working Group grew out of the recent AGU Chapman Conference: “Long Time-Series Observations in Coastal Ecosystems: Comparative Analyses of Phytoplankton Dynamics on Regional to Global Scales” (convened by James Cloern and Nenad Smodlaka, October 8-12, 2008, Rovinj, Croatia). This conference convened over 150 researchers, managers and agency representatives from many countries and provided an excellent opportunity to identify and compare long-term coastal phytoplankton data sets broadly distributed throughout the northern and southern hemispheres.

There was a strong consensus at this conference that a more detailed, global comparison of phytoplankton time series would be timely, technically feasible, and an extremely valuable next step to more fully understand commonalities and contrasts with regard to ecological responses to natural and man-made changes captured by our global network of coastal phytoplankton time series.

Such an analysis must be an international cooperative effort. The relevant data sets are in many places and have been collected by many independent researchers, agencies and nations. Many of the necessary data are available now, and the Working Group can begin immediately. Endorsement and sponsorship by SCOR will help us attract and retain approvals and financial support from national agencies.

The Chapman Conference was a meeting organized by individual scientists and managers; not by an organization. The WG formation would carry forward the momentum by helping set up the platform to work with scientists in various regions on a continuing basis for several years and also possibly to take a lead in promoting a second Chapman conference in the near future (as yet, there is no actual activity for organizing the second Chapman conference). Without an organizational approach in the form of a SCOR WG, there will be no platform to gather scientists to more fully analyze and synthesize these valuable data sets.

2. The Nature of the Scientific Opportunity and Management Needs

Phytoplankton

Phytoplankton are dominant marine primary producers; they mediate nutrient flux and cycling as well as transfer of organic matter to higher trophic levels, including invertebrate grazers, planktivorous fish, and carnivores. Hence, they are a key link between nutrients and secondary production. As key primary producers, phytoplankton reflect immediate effects of changes in the input of nutrients in coastal ecosystems. Because different phytoplankton groups require different nutrient ratios, their composition responds to changes in the ratios of ambient nutrients. For example, diatoms require silicate and their relative abundance may be regulated by Si concentrations relative to other nutrients. Phytoplankton productivity and floristic composition are subject to physical forcings such as horizontal exchange between estuaries and the open sea (Cloern et al. 2007) and vertical mixing regimes, and they are also regulated by light fluctuations, and temperature. Changes in phytoplankton productivity and composition can be driven by climatic forcing and variability such as monsoons (Yin 2002), typhoons or hurricanes (Paerl et al. 2001, 2006) and rainfall (Paerl 1995; Adolf et al. 2006). In addition, phytoplankton are broadly distributed and abundant, and can be quantified by relatively simple and intercomparable sampling methods. Finally, demographic traits of phytoplankton make them particularly suitable for comparative analysis of ecosystem changes across regional to global scales.

Regional and Global Comparisons

We believe that large-scale (between-region and between-ocean) comparisons of phytoplankton time series are the essential next step. Local- and regional-scale observational programs are maintained in coastal marine waters of all continents, but their data remain largely isolated. Our

goal is to locate, assemble, and synthesize multi-decadal observations to obtain quantitative and descriptive depictions of phytoplankton variability as an indicator of environmental change. We envision a global phenology of phytoplankton at the land-sea margin and a conceptual model from which coastal ocean observing systems can be built. As a logical outgrowth of (and next step following) the Chapman Conference, the working group will focus on a comparative analysis of ecosystems to address three guiding questions:

1. *What are the dominant scales of variability in phytoplankton biomass, abundance, floristic composition, species composition, and/or species diversity? Is there evidence for secular trends or regime shifts? With which criteria can we best differentiate long-term from episodic, seasonal and interannual signals?*

2. *Is there evidence for external forcings of variability and change (e.g., effects of climate change, basin scale oscillations, land-based inputs, atmospheric deposition, alien species)? Are changes coherent in space and/or time?*

3. *Are there consistent patterns among ecosystems in terms of relationships between environmental drivers, responses in phytoplankton biomass and changes in species/floristic composition?*

To date, relatively few between-region comparisons of phytoplankton time series have been completed. All previous comparisons have been at smaller scales (within an individual current system, or at one ocean basin), compared to the global scale that include inter-regional comparisons that we are proposing.

The Chapman Conference was focused on the land-sea interface where changes are driven by complex interactions between human disturbance and climate variability. This proposed working group will continue to focus on coastal ecosystems influenced by connectivity to land: estuaries, river plumes, mangroves, bays, lagoons, inland seas.

Existing time series data of phytoplankton

Many researchers and governmental agencies around the world have relied on phytoplankton as a key indicator of water quality monitoring programs and many data sets have been presented in the Croatia AGU Chapman conference. Those data sets are included in Table 1 (attached at the end of this document).

Data availability for the proposed WG

We already have a number of data sets with excellent global representation of coastal systems that are available for the WG. They will be contributed by the members and associate members,

as shown in Table 2.

Table 2. Data available from participants of the proposed WG members and associate members.

Name	Country	Ecosystem	Series
Peter Thompson	Australia	South Pacific Ocean	1993-2007
Robert Le Borgne	New Caledonia, France	West Coast of South Africa SW Pacific	1993-2007
Jacob Carstensen	Denmark	Kattegat, Atlantic	1993-2007
James E. Cloern	U.S.	North & South San Francisco Bay, Western Paficic	1969-2007
Lawrence W. Harding, Jr.	U.S.	Chesapeake Bay, North Atlantic	1989-2007
Snejana P. Moncheva	Bulgaria	Black Sea	1954-2003
McQuatters-Gollop, Abigail	UK	CPR (North-East Atlantic including European shelf; North Sea, Irish Sea, English Channel, North-West Atlantic including Scotian Shelf, Grand Banks; North Pacific)	1948-2007
N. Ramaiah	India	Bay of Bengal, Indian Ocean	1962-1965, 2001-2006
Clarisse Odebrecht	Brazil	Patos Lagoon estuary and Cassino Beach surf-zone, South America (32º S)	1986, 1988-1990, 1992-2009
Hans W. Paerl	U.S.	Neuse River-Pamlico Sound, Atlantic	1993-2006
Elgin S. Perry	U.S	Chesapeake Bay, Atlantic	1985-2004
C J M Philippart	The Netherlands	Wadden Sea, North Sea	1995-2004
Ted Smayda	U.S.	Narragansett Bay, Atlantic	1974-2007
Kedong YIN, Paul J. Harrison	China (Hong Kong)	Subtropical South China Sea	1991-2004

A. Zingone	Italy	Gulf of Naples, Mediterrenean Sea	1984-1991, 1995-2009
N. Ramaiah	India	Bay of Bengal	1962-1965, 2001-2006

We will consult with other individuals (in Table 1) about their willingness to participate in our WG analysis and synthesis. Scientists and managers are willing to contribute their data sets for specific purposes such as synthesis, correlations, and comparisons in general, which has been demonstrated in Cloern and Jassby (2008) who received over 100 data sets (the condition was that the data would only be used for this specific purpose). In addition, we hope to have a second Chapman conference in the near future under the SCOR WG leadership, which would provide the opportunity for identification of more data sets and to conduct a more thorough regional and global time series synthesis.

The analysis and synthesis of many datasets are crucial to achieve the WG objectives. The WG members and associate members have the necessary skills to complete the tasks proposed in this WG since they have all conducted analysis and synthesis of their data for regional ecosystems. For example, Cloern and Jassby (2008) have synthesized many data sets in the paper "Complex seasonal patterns of primary producers at the land-sea interface". The WG participants have two statisticians, Carstensen and Perry. The WG participants not only have skills in manipulation of large databases, but also have comprehensive knowledge of phytoplankton ecology in the context of environmental change, anthropogenic influence and climate change. Lastly, they have contributed numerous publications emphasizing the importance of synthesizing human and climatic drivers of phytoplankton community structure and function.

The data sets listed above are by no means complete (they were from the Chapman Conference only). The CPR dataset, although not included in the original proposal, is included here as the CPR has comprehensively sampled phytoplankton biomass as well as the abundance of nearly 200 phytoplankton taxa in coastal ecosystems including the North Sea, Irish Sea, English Channel, European Shelf, North Pacific, Grand Banks, and Scotian Shelf as well as the open ocean since 1948. No other ecological datasets have sampled marine and coastal plankton at this comprehensive spatial and temporal scale.

Data Archiving and Database Centre

There is certainly a need for compiling and archiving those data sets into a mega database. We will facilitate migration of individual datasets to a permanent and secure electronic archive based on the scientist's willingness of participation and data accessibility. Requirements for development of a fully-stocked phytoplankton data-base greatly exceed the resources of this WG. However, we expect to produce a small working proto-type, based on some existing archive (to be identified) to demonstrate the value of sharing data through an international

databse, as demonstrated by SCOR WG125: Global Comparisons of Zooplankton Time Series.

Methodological opportunities and issues

Several methodological issues affect the analysis of phytoplankton time series and only a brief summary is given here. However, even though these issues will complicate our work, we can still obtain a meaningful global comparison.

The first issue is diversity of the sampling methodology. No phytoplankton sampling method is perfect, and there have been differences in sampling methodology both within and between data sets, particularly for earlier data. However, we do not expect these differences to be a serious technical barrier to between-region comparisons. A key reason for this is that our analysis focuses on comparisons of anomaly time series rather than of regional climatology. Hence, we are primarily interested in the temporal variability of relative abundance, not the spatial variability of absolute abundance. Several of the proposed WG members have expertise in evaluating effects of changes in sampling methodology within individual time series.

A second issue is consistency of taxonomic identification within and among data sets. Again, we are primarily comparing anomalies relative to local norms, and looking for when, where, and how long the community changes. We also expect that all or most of our analyses will be weighted on the better-known taxa that dominate the community in each region.

A third issue is the volume, accessibility, and diversity of data. The situation here is much improved over even a few years ago. Good computer tools for dealing with the diverse origin and moderately large data sets are now more available, cheaper, more flexible and user-friendly. We anticipate that this trend will continue. Although data management work will be necessary, we do not expect that electronic assembly and consolidation of the phytoplankton data sets will be a major technical problem. In fact, we have already assembled several key data sets as part of the Chapman Conference.

The final issue is the use of statistical tools. During the Chapman Conference, several statistical experts were invited to help participants to perform statistical analyses on their own data set. They demonstrated how to deal with temporal and spatial autocorrelation, and with data gaps. This knowledge will be utilized by our SCOR WG in the next phase of global time series analysis. Application, evaluation, and bundling of these statistical tools for distribution/publication will be another important WG product.

3. Proposed Terms of Reference

- Identify existing long time series of phytoplankton data in coastal oceans around the world

- Facilitate migration of individual data sets to a permanent and secure electronic archive (Requirements for development of a fully-stocked phytoplankton data-base greatly exceed the resources of this WG. However, we expect to produce a small working proto-type, based on the existing archive (to be identified) to demonstrate the value of sharing data through an international database.)
- Develop the methodology for global comparisons for within-region and within-time-period data summarization (e.g. spatial, seasonal and annual averaging, summation within taxonomic and functional group categories). The goal is to clarify what level of detail provides the optimal tradeoff (i.e. information gain vs. processing effort).
- Based on the above, develop priorities and recommendations for future monitoring efforts and for more detailed re-analysis of existing data sets.
- We will carry out a global comparison of phytoplankton time series using (in parallel) a diverse suite of numerical methods. We will examine:
  - Synchronies in timing of major fluctuations, of whatever form.
  - Correlation structure (scale and spatial pattern) for particular modes of phytoplankton variability (e.g. changes in total biomass, species composition shifts, among different geographic distribution).
  - Amplitude of variability, both for total biomass and for individual dominant species, and a comparison to the amplitude of population fluctuations.
  - Likely causal mechanisms and consequences for the phytoplankton variability, based on spatial and temporal coherence with water quality time series.
- Through comparative analysis, we will address the 3 guiding questions.

4. Time Frame and Expected Products

We will begin work in 2010 and will continue for three years. We will convene annual WG meetings (each about 4-5 days), and a larger open attendance workshop or conference in the final or penultimate year. For each year, expected activities and products include:

Year 1: Summarize and evaluate methods, results, and questions arising from the phytoplankton time series analyses that have been completed to date. For the proposed new comparative analyses, select and prioritize the set of regional time series, and the suite of variables from each time series that will be compared (e.g. total phytoplankton biomass, major groups and/or species-level phytoplankton taxonomic composition, phenology, and physical and biological environmental indices). Identify and address obstacles to pooled analyses (e.g. incomplete processing, differences in formatting, differences in resolution). Develop the "best practice" recommendations for data sampling and analysis methodologies.

Year 2: Begin comparative analyses. Evaluate sensitivity and specificity of data analysis (statistical) tools, and improve their availability and "user-friendliness". Identify time scales and time intervals of particular interest. Post selected tools and data on a web or ftp site

(initially closed, and eventually public).

Year 3: Complete comparative analyses of phytoplankton and environmental time series, incorporating any new data that have become available during years 1-3. Identify synchronies (if any) in timing of fluctuations, and quantify correlation time and space scales. Prepare interpretive paper(s) for symposium presentation and publication. Prepare recommendations for "best practice" time series sampling and analysis methodologies.

5. Proposed Working Group membership

Our primary selection will be based on a broad experience with phytoplankton time series, combined with geographic representation and local knowledge of the content for each regional data set. Our revised proposal includes the following full members and assocate members.

Full Members

Yin, Kedong (co-chair)	1) School of Marine Sciences, Sun Yat-Sen (Zhongshan) University, China 2) Griffith Univeristy, QLD, Australia	k.yin@griffith.edu.au
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Cloern, James E.	U.S. Geological Survey, Menlo Park, California, USA	jecloern@usgs.gov
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Li, Ruixiang*	First Institute of Oceanography, State Oceanic Administration, China	liruixiang@fio.org.cn
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Zingone, Adriana	Stazione Zoologica A. Dohrn, Villa Communale, Italy	zingone@szn.it

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** supported by NOAA

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** Prof. Yoo is supported by PICES
*** Prof. Zhu, is supported by SOA, China (SCOR-China Branch)

Brief description of member profiles.

Co-Chair, Kedong Yin

His data set will cover subtropical coastal waters in the South China Sea, which receives the outflow of the 2nd largest river (Pearl River) in China.

Yin's research interests include: coastal dynamics of nutrients; eutrophication processes; ecology and oceanographic processes of harmful algal blooms, in coupling processes with environmental variability, and climate changes; and a plenary speaker on "the dynamics of phytoplankton species composition in subtropical waters of south China during the last 15 years".

Co-Chair, Hans W. Paerl

His interest is to examine how phytoplankton composition change responds to natural disasters.

Paerl is the Kenan Professor of Marine and Environmental Sciences and his research interests include; microbially-mediated nutrient cycling and primary production dynamics of aquatic ecosystems, environmental controls of harmful algal blooms, and assessing the causes and consequences of man-made and climatic (storms, floods) nutrient enrichment and hydrologic alterations of inland, estuarine and coastal waters. His studies have identified the importance and ecological impacts of atmospheric nitrogen deposition as a new nitrogen source supporting estuarine and coastal eutrophication. In 2003, he was awarded the G. Evelyn Hutchinson Award by the American Society of Limnology and Oceanography for his work in these fields and their application to interdisciplinary research, teaching and management of aquatic ecosystems.

Jacob Carstensen

His data set represents a temperate inland sea (Kattegat) of the Atlantic Ocean.

Carstensen is a statistician working within marine ecology, in particular long-term trends of ecosystem quality indicators in response to anthropogenic pressures. Particular scientific fields of interests are: biogeochemical processes, phytoplankton community structure and bloom mechanisms, hypoxia, and nutrient management for marine ecosystems.

James E. Cloern

His data are from San Francisco Bay and represent many phenomena associated with

anthropogenic influence vs climate change.
Cloern has strong expertise in phytoplankton ecology, particularly phytoplankton response to eutrophication and climate changes. He is very experienced in the synthesis of long term data set, and wrote "Phytoplankton bloom dynamics in coastal ecosystems: a review with some general lessons from sustained investigation of San Francisco Bay, California" in 1996. In 2001, he comprehensively reviewed global data in coastal waters and wrote a conceptual review that was published in Mar Ecol Prog Series, "Our evolving conceptual model of the coastal eutrophication problem", which has greatly stimulated coastal eutrophication research. The paper has been cited 373 times.

Paul J. Harrison

Harrison is a biological oceanographer with expertise in nutrient dynamics and phytoplankton ecology and recent interest in eutrophication, harmful algal blooms and hypoxia. He is a member of SCOR WG 132 "Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems" and will coordinate activities between the two WGs if this WG is funded.

McQuatters-Gollop, Abigail (female)

Working on the CPR data set which includes a measure of phytoplankton biomass as well as the identification and abundance of nearly 200 phytoplankton taxa in the North Sea, Irish Sea, English Channel, European Shelf, North Pacific, Grand Banks, and Scotian Shelf as well as the open ocean since 1948.

Clarisse Odebrecht (female)

Her data are from South America coastal temperate waters (Patos Lagoon estuary and sandy beach surf-zone).
She is a Professor and leader of the research group: Ecology of Marine Phytoplankton and Microorganisms at the Federal University of Rio Grande-FURG, Brazil. Her main research topics include: taxonomy and ecology of marine phytoplankton, harmful algal blooms, coastal eutrophication and studies on microalgae in marine aquaculture.

Katja Philippart (female)

Her data are from the Wadden Sea, another example where major engineering works have occurred along the coast.
Philippart is a marine ecologist and her research combines laboratory experiments, field studies, statistical analysis of long-term field observations and modeling techniques to investigate the underlying mechanisms of long-term dynamics within shallow marine coastal communities. Her emphasis is on understanding the role of human influences (eutrophication, fisheries and global warming) within these ecosystems in regulating primary and secondary producers, within the North Sea, Venice Lagoon and the Banc d'Arguin. At present, she coordinates relevant research projects, viz. JetSET (long-term field observations in the western Wadden Sea), and the recently funded national research project (2008-2013) dedicated to monitoring primary production in the western Wadden

Sea as a baseline for management of human activities in coastal waters (IN PLACE). She is the Editor-in-Chief of the Journal of Sea Research since 2000, co-author of Marine Coastal Dimension of Climate Change in Europe (EU-IES, 2006, Ispra), and the leading author of Climate Change Impacts on the European Marine and Coastal Environment (ESF-Marine Board, 2007, Strasbourg).

N. Ramaiah

His data represent coastal tropical waters in the India Ocean.

Peter Thompson

His data represent temperate waters in the south Pacific Ocean.

Dr Thompson is a Principal Research Scientist with CSIRO Marine and Atmospheric Research and Head of the CSIRO Collection of Living Microalgae. His research spans phytoplankton environmental issues and bioapplications of microalgae. Working with oceanographic investigation over 20 years, Dr Thompson has combined ecophysiological studies in culture with field studies to elucidate regulation of phytoplankton productivity and species composition in south eastern Australian waters. Within CSIRO, nationally and internationally Dr Thompson's research informs system-wide environmental management and prediction of phytoplankton dynamics and algal blooms through biogeochemical modelling.

Adriana Zingone (female)

Her data set are in the Gulf of Naples, Mediterranean Sea

Zingone is an expert in taxonomic and morphological studies on marine microalgae, and spatial distribution of phytoplankton diversity in marine waters. Her research findings based on biological time series data contributed to revising paradigms and myths of phytoplankton ecology. She also reviewed seasonal patterns in plankton communities in a pluri-annual time series at a coastal Mediterranean site (Gulf of Naples): an attempt to discern recurrences and trends.

6. Funding

We will contact various organizations such as LOICZ, IMBER, GEOHAB, PICES, IOC, ICES and Census of Marine Life and expect to attract co-sponsorship and additional financial support in the form of travel funding for associate WG members, especially from the developing countries.

Full members from developed countries will be asked to cover part of the cost of their own travel and accommodation from other sources, if SCOR has a budget limitation to fully support our proposed WG.

Our proposal has been strongly supported by PICES and PICES will fully support an associate member, Sinjae Yoo.

7. Interactions with other organizations or programs.

We will maintain our interactions with organizations such as IMBER, LOICZ, GEOHAB, PICES, IOC and CoML during the WG's active period. For example, we will send them our annual meeting notices before meetings and our annual reports for their feedback. Paul Harrison is a full member of WG132 and Katja Philippart is executive member of IMBER.

We will try to establish a strong interaction and working relationship with the SCOR WG 125 on zooplankton time series and SCOR WG 132 on HABs. This interaction will be very beneficial as they are dealing with the similar challenge of analyzing global time series data sets.

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Table 1. Data sets presented at the Chapman Conference in 2007, Croatia.

Theme 1: dominant scales of variability in phytoplankton biomass, abundance, floristic composition, species composition, and/or species diversity			
Name	**Country**	**Ecosystem**	**Series**
Paulo C. Abreu	Brazil	Patos Lagoon Estuary	1986-1990, 1993-2007
Peter Thompson	Australia	Huon Estuary, Tasmania	1996-2005
H. O. Briceño	U.S.	Biscayne Bay, Florida Bay, Florida Shelf	1989-2007
Francisco.P. Chavez	U.S.	Monterey Bay	1988-2007
James E. Cloern	U.S.	North & South San Francisco Bay	1969-2007
Valerie David	France	Gironde Estuary	1978-2003
S. Fonda Umani	Italy	Gulf of Trieste	1986-2005
Miles Furnas	Australia	Great Barrier Reef Lagoon	1992-2007
S.A. Gaeta	Brazil	Brazil Coastal Waters	2004-2007
Charles L. Gallegos	U.S.	Rhode River Estuary	1969-2007
Amatzia Genin	Israel	N Gulf of Aqaba	1988-2007
Rita A. Horner	U.S.	Washington Coast	1997-2007
Arantza Iriarte	Spain	Bilbao & Urdaibai . Estuary	1997-2007
Jacco C. Kromkamp	The Netherlands	Oosterschelde/Westerschelde	1987-2006
Robert Le Borgne	France	Ivory Coast, New Caledonia	1969-1979, 1979-1989
WKW Li	Canada	Bedford Basin	1967-2007
Michael W. Lomas	U.S.	Bermuda Atlantic Series	1989-2007
Emma Orive	Spain	Nervion River Estuary	2000-2006
Elgin S. Perry	U.S	Chesapeake Bay	1985-2004
N. Ramaiah	India	Bay of Bengal	1962-1965, 2001-2006

Diana Sarno	Italy	Gulf of Naples	1984-1991, 1995-2008
Dietmar Straile	Germany	Lake Constance	1980-2006
Sanna Suikkanen	Finland	Northern Baltic Sea	1979-2003
Alexander Vershinin	Russia	NE Black Sea	2001-2006
Hidekatsu Yamazaki	Japan	Tokyo Bay	1996-2006
Theme 2: evidence for external forcings of variability and change			
Name	Country	Ecosystem	Series
Ana B. Barbosa	Portugal	Ria Formasa Lagoon	1991-1993
Vanda Brotas	Portugal	Tagus Estuary	1999-2007
Rita B Domingues	Portugal	Guadiana River Estuary	1999-2005
Naomi Greenwood	U.K.	Liverpool Bay	1989-2006
Malcolm S. Robb	Australia	Swan Canning Estuary	
Bradley Eyre	Australia	Moreton Bay & Brunswick Estuary	1984-1991; 1995-2007
David G. Borkman	U.S.	Narragansett Bay	1959-1997; 1999-2006
Jonathan H. Sharp	U.S.	Delaware Bay	1980-2003; 1950s – present
Larry W. Harding, Jr.	U.S.	Chesapeake Bay	1989-2007
Hans W. Paerl	U.S.	Neuse River-Pamlico Sound	1993-2006
Clarisse Odebrecht	Brazil	Patos Lagoon Estuary, Cassino Beach	1987, 1989-1990, 1992-2006
M Ribera d'Alcalà	Italy	Gulf of Naples	1979-2006
Alina Tunin-Ley	France	Ligurian & Tyrrhenian Seas	1908-1914, 1929-1931, 1969-1970, 1984, 1988, 2002-2005

Nenad Smodlaka	Croatia		1987-2007
Jacob Carstensen	Denmark	Kattegat	1993-2007
Daniel Conley	Sweden		
Hans Christian Eilertsen	Norway	Norwegian Coast/Barents Sea	1974-2007
Karen Helen Wiltshire	Germany	North Sea Helogland	10 years
Xavier Desmit	The Netherlands	North Sea	1975-2003 ; 1990-2006 (Phyto)
Martina Loebl	Germany	Belgian, Dutch, German Coastal	1990-2005
C J M Philippart	The Netherlands	Wadden Sea	1995-2004
Jennifer L. Martin	Canada	Bay of Fundy	1980-2007
Michael L. Parsons	US	N Gulf of Mexico	
Trevor Platt	Canada	NW Atlantic, remote sensing	1990-2005
Theme 3: consistent patterns among ecosystems in terms of relationships between environmental parameters, phytoplankton biomass and changes in species/floristic composition			
Name	Country	Ecosystem	Series
Malcolm C. Baptie	U.K.	North Sea, UK NE coast	1969-2007
Mauro Bastianini	U.K.	Gulf of Venice	1986-2007
Suncica Bosak	Croatia	N Adriatic Sea	1998-2006
Eileen Bresnan	Scotland	NE Scotland Coastal	1997-2007
Maria Degerlund	Norway	Norwegian coast/Barents Sea	3 decades
R. H. Freije	Argentina	Bahía Blanca Estuary	1978-2006
Inga Hense	Germany	Baltic Sea	1975-2006
Carlton D. Hunt	U.S.	Boston Harbor, Cape Cod Bay,	1992-2008

		Massachusetts Bay	
Tapan Kumar Jana	India	Sundarban Mangrove Forest	1988-2001
R. Kraus	Croatia	Northern Adriatic	1972-2006
Dongyan Liu	China	Jiaozhou Bay	
A. Lincoln MacKenzie	New Zealand	Marlborough Sound, Tasman & Golden Bays	1993-2007
Ivona Marasović	Croatia	Northern Adriatic	1962-1982
Snejana P. Moncheva	Bulgaria	Black Sea	1954-2003
Patricija Mozetic	Slovenia	Gulf of Trieste	1984-2006
Tatyana Osadchaya	Ukraine	Black Sea	1998
Edward J. Phlips	U.S.	Indian River Lagoon	1997-2007
Igor G Polikarpov	Ukraine	Sevastopol Bay	1937-1938, 1960-1968, 2001-2007
Kevin G. Sellner	U.S.	Chesapeake Bay	1984-2007
Ted Smayda	U.S.	Narragansett Bay	1974-2007
Kuninao Tada	Japan	Seto Inland Sea	1991-2006, 1973-2005
Norbert Wasmund	Germany	Baltic Sea, Mecklenburg Bight	1979-2006
Kedong YIN	Hong Kong	Hong Kong Coastal	1991-2004
A. Zingone	Italy	Gulf of Naples	1984-1991, 1995-2009

Appendix 2: SCOR WG 137. Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations

Data and Policies

One of the first practical objectives for WG137 is to identify and assemble a global collection of phytoplankton data sets, pre-process them into a standard machine and human readable format, and make them accessible (behind password controls) to the members of WG137. By working through a centralized data repository, we can facilitate easier data access across the entire working group and reduce the chances of sharing different versions or revisions of the same data set.

As a WG137 data provider, you will only have to service the one data call by the working group's repository. As a WG137 data user, you can access all of the other data sets in the global collection via this centralized repository (i.e. one-stop-shopping). As an added bonus, the centralized system can offer the data in a variety of standard data formats (ranging from "R-friendly" and "Matlab-friendly" tables and columns to pretty much any other format the group requires for their work) and various visualizations and graphical presentations.

WG137 will be using, and expanding upon, the time-tested SCOR zooplankton time series group's (WG125) data handling system. Todd O'Brien, data manager for WG125 and now WG137, will work with us to tailor this system to our exact data needs and will help us handle the large volumes of data anticipated during this working group's duration.

For example, during its five-year working period, the WG125 zooplankton group assembled over 140 zooplankton time series which collectively contained over 700 variables. Based on initial data queries for the North Atlantic alone by the new ICES phytoplankton group (WGPME), the data collection of WG137 could easily be double or triple the WG125 zooplankton collection.

Todd has shared his WG125 experiences to get WG137 started efficiently, helping address technical issues (what format and how we should submit data to the WG137 repository) and other important issues such as data control and authorship. Below is guidance from Todd based on his WG125 experiences.

DATA REQUESTS AND SUBMISSIONS:

Setting a "cut-off date" for the data analysis:

When WG125 started in 2005, it set an analysis and climatology cut-off date of December 31, 2005. This allowed time for all of the zooplankton samples to be processed and their data submitted prior to when the heavier WG125 analysis phase started in 2006 and 2007. Todd proposes that a analysis and climatology cut-off-date of December 31,

2010, be used for WG137. While all of the WG137 data will not be ready (or even sampled) before our October 2010 meeting, the majority of the data would be able to be in the repository and in "final form" by the time of the 2011 meeting and analysis phase started.

The initial data request that will be sent out by WG137 in the early summer of 2010 should only request data through the end of 2008. This two-year initial delay should help scientists "warm up" to the idea of sending their data to the group's effort. WG137 can then make a second request to all of the contributors during the summer of 2011, asking for a two-year update to bring the 2008 time series up to 2010.

HOW TO SUBMIT DATA TO WG137:
Todd can handle almost any data format provided in simple ASCII (text, CSV) files or Excel spreadsheets. (The data contributor does not need to spend their time pre-formatting the data before submission.)

The data can be sent in a single file or in multiple files (however the data contributor tends to work with the data themselves). Todd did make a few simple requests in terms of the data and date values themselves:

1. Please provide the data values in a basic, raw format. Please do not provide data in a log transformed format. (If this is the only form available, then provide information on how the data were log transformed (e.g., log(x) or log(x+1) or log(x+0.1) so the raw values can be reverse calculated). Likewise, pre-calculated anomalies really cannot be used by the repository data system. The system itself will calculate these values (using the WG137 selected methodology) from the raw data, ensuring that the methods and calculations are consistent across the full data collection.
2. Please provide the (calendar) sampling dates in their original form. This means original "year +month + day" dates can and should be submitted in that format rather than as pre-calculated weekly or monthly averages. (If the data are only available in pre-calculated weekly or monthly averages, that is okay. The data system can still use them. Again, please provide the most basic data and let the data system do the work for you.)
3. Please include a latitude and longitude location for the sampling site(s). If the data are from a single station, a single latitude and longitude are fine. If the data are from a transect, please provide the latitude and longitude of the starting and ending positions. If the data are compiled from a spatial "box" or region, please provide information on the corners of the "box" or at least the longitude and latitude of its center point.
4. If co-sampled or corresponding hydrographic data (i.e. temperature, salinity) and/or nutrient data are available for the phytoplankton site, please include those when possible. These can be submitted as a separate file or spreadsheet if they are not already part of the phytoplankton data file.

Data Control and Authorship:
Based on experiences within WG125, there really were no issues with data control or authorship. The data were available from a password-protected Web site, and only those people doing the actual number crunching generally accessed the data compilation. If potential data contributors still have reservations about sending data, Todd suggest that all data compiled from the initial WG137 data calls will not be made accessible to the other WG137 members until after first meeting in October. (We can address any issues or concerns at that point.)

Before we will discuss various issues related to access to the data sets at the first WG137 meeting, we need data to work on the data sets now and therefore, the data compilation should start now. We suggest that before he/she is given the password to access the data sets. a person should agree:

1) his/her usage of data sets is only for the purpose of WG work, i.e., not for the publication or other purposes;

2) not to share the given password with others.

2.3 Working Group Proposals

2.3.1 Global Analysis of coldwater Coral Ecosystems (GLACES)

Proposal for a SCOR Working Group
Global Analysis of cold-water Coral Ecosystems - GLACES

Summary
We are witnessing exponential growth in cold-water coral research. Recent discoveries have revealed cold-water corals as significant structural habitats on continental margins, seamounts, and mid-ocean ridges. Solitary corals are even found in the abyssal ocean. Many species are long-lived, and some form long-lasting reef and mound structures providing unique archives of faunal biodiversity and oceanic change. However, there has been no systematic research programme that links the interdisciplinary fields of coral biology, ecology, biodiversity and palaeoceanography at the global scale. A programme of this scope would only be possible through interdisciplinary, international collaboration. The first attempt to create an ocean basin-scale programme, the Trans-Atlantic Coral Ecosystem Study 'TRACES', was launched in February 2008 and has gathered momentum by bringing a disparate group of ecologists, geologists and palaeoceanographers together to develop its Science Plan. In early 2009, European members of the TRACES community put forward 'EuroTRACES', a European Science Foundation research programme, and this application was approved in early 2010. EuroTRACES will focus on the North Atlantic Ocean.

This SCOR Working Group proposal seeks to establish an international group to build on the momentum generated through TRACES to start work on development of a truly international, global research programme. This Global Analysis of cold-water Coral Ecosystems - GLACES - will develop an integrated global cold-water coral study, ensuring consistency in research approach, and effective reporting. It will produce a planning document outlining the programme and this overview will be widely distributed both in print and online. We also plan a number a specialised, peer-reviewed papers alongside materials of wider appeal including online summaries and downloadable slide sets on each of the GLACES thematic areas. The SCOR-GLACES working group will begin to design and co-ordinate a concerted field programme for the global ocean. It will follow clear terms of reference with expertise across the thematic areas of the programme encompassing ecosystem processes, climate records, and overarching issues relevant to all aspects of the programme.

Rationale & Scientific Background
The last ten years have seen great advances in our understanding of cold-water corals as significant ecological engineers on continental margins, offshore banks, seamounts and canyons [1, 2]. Stony (scleractinian) cold-water corals can develop large deep-water reef frameworks providing complex three-dimensional habitat for a spectacularly diverse associated fauna. Other groups of corals, such as ·gorgonians and black (antipatharian) corals also provide long-lasting habitat, notably on

seamounts and mid-ocean ridges. Indeed, recent dating studies show that antipatharian corals can live for thousands of years [3]. But cold-water corals are not only a biological or ecological curiosity. They form perhaps the most structurally complex and biodiverse deep-sea habitats and their long-lasting skeletons and the mound structures they form provide new archives of the variability of ocean properties during climate change [4-7]. Possibly more than any other habitat, cold-water coral reefs are threatened by ocean acidification and further study of their health and history is crucial at this moment in time.

Ecosystem research

Linkages & connectivity: Cold-water coral habitats provide a natural laboratory to study genetic relationships between spatially separated marine populations. Sessile benthic marine species such as corals may be genetically connected (i.e. exchanging genetic material) by larval dispersal. Understanding how one coral population is (or is not) genetically related to others is vital to understanding ecosystem dynamics in space and time and to designing ecologically coherent marine protected areas.

Biodiversity & biogeography: Cold-water corals are among the most three-dimensionally complex structural habitats in the deep sea. As such they provide a great variety of physical niches and support high biodiversity [8-10]. In turn the variety and spatial patchiness associated with cold-water coral habitats creates significant variation in species between habitats, promoting high species turnover [II, 12]. However, while they clearly form biodiversity 'hotspots' our understanding of spatial biodiversity and biogeographic patterns in cold-water coral habitats remains poorly developed. This is largely because studies to date cannot be compared due to variable sample collection protocols (e.g. trawl, submersible, box corer) and inconsistent taxonomic resolution (differing expertise between research groups leading to biases in the species subsequently identified). The GLACES programme proposes an ambitious study to examine biodiversity and biogeographic patterns building upon work now beginning through TRACES. Analytical consistency and co-ordinated use of international taxonomic experts organised through networking activities will reveal new species and revisions to existing species descriptions. Such a programme of work will complement and add to previous large-scale biodiversity initiatives, such as the Census of Marine Life, by targeting biodiverse cold-water coral habitats likely to contain many undescribed species.

Coral biology: Information on critical aspects of cold-water coral biology, such as feeding, physiology, trophic ecology, growth patterns and reproductive strategies, has only begun to become available in recent years but remains restricted to very few species. Understanding reproductive and larval biology is central to understanding population connectivity. Furthermore, lack of physiological data limits our ability to understand cold-water coral responses to ocean warming and acidification, both causes of great current concern. In the North Atlantic, EuroTRACES will support investigation of the reproduction, feeding ecology, growth and ecophysiology of major habitat-forming cold-water corals. Internationally, GLACES will apply these approaches to cold-

water coral habitats globally. It will capitalise on recent advances in maintaining cold-water corals under controlled laboratory conditions allowing studies of coral response to predicted scenarios of ocean warming and acidification. Finally, repeatedly sampling field sites where year-round access is achievable can provide new insights regarding reproductive periodicity in a seasonal context.

Climate records research

The GLACES palaeoceanographic projects have two overall aims: first to examine environmental effects on cold-water coral habitats and biodiversity, and second to understand the role of ocean circulation in a changing Earth climate system. These will be addressed using investigations of the recent past (millennia) coupled with instrumental records to provide a clearer picture of anthropogenic changes to ocean chemistry and circulation. Records ofthe past 25,000 years and beyond, on the other hand, can provide unique information on ocean circulation during times of radically different mean climate and rapid climate change. GLACES research projects on climate records will contribute to the following major issues:

- Links between past changes in ocean circulation and coral vitality
- Links between global climate and the rate of ocean circulation
- Recent and long-term history of the carbon cycle and ocean acidification
- Deep-ocean productivity, nutrient cycling and trophic changes

For the study of the past ocean, cold-water corals offer a unique combination of uranium-rich, unbioturbated skeletons that serve as faithful archives of the water in which they grew. Using uranium disequilibrium dating, it is possible to independently constrain a fossil coral's age [13, 14]. Because the coral's skeleton is a banded archive with nearly perfect stratigraphy, it records rapid climate change events at ice core-like resolution, thus surpassing the ability of many ocean sediment-based measurements to record climate change. These features of cold-water corals have been used to track the extent of bomb ^{14}C penetration to the ocean interior and to document the speed with which the deep ocean participates in past climate change over timescale of just a few decades. This unique new archive of past climate change is just beginning to be widely exploited by the research community.

In addition, the past distribution of fossil Scleractinia in space and time has shed new light on the extent of population movements in the deep sea. Records from the New England Seamounts show that coldwater corals thrive at times of rapid climate change and are nearly absent during the Holocene [6]. In the Northeastern Atlantic, on the other hand, coral development is greatest during interglacials at higher latitudes [15] and during glacial periods at mid-latitudes [16, 17]. These differences in population dynamics provide an important target for modern studies of coral ecosystems to explain how changes in the enviromnent (ocean acidity, circulation, temperature and productivity for instance) work to structure the community. This is one of several fruitful new lines of research between ecology and palaeoceanography that our SCaR working group plans to develop. Over and above these ambitions the GLACES Working Group will engage with PAGES

(Past Global Changes), the well-established International Geosphere-Biosphere Programme (IGBP) project, since there are many aspects where our research objectives complement PAGES overall goals (www.pages-igbp.org).

Further studies will capitalise on the wide geographic sampling planned during TRACES and GLACES to run proxy calibration exercises (e.g. to test temperature proxies across latitudinal transects, to calibrate nutrient proxies, and to refine proxies for past ocean ventilation, intrinsically linked to past atmospheric CO_2 levels). The perceived paucity of cold-water corals on the seafloor and in existing museum collections remain significant limitations to the more widespread use of cold-water corals in climate studies. A key goal, and a pressing job for the SCOR working group, is to organise the existing information about where corals have been collected and to identify the most urgent needs for new field collection. Therefore work to co-ordinate suitable collections through research cruise proposal planning is vitally important.

Overarching issues

Mapping & habitats: High-quality mapping and habitat characterisation will underpin all GLACES studies and take advantage of the survey and processing improvements made in recent years. Existing relevant regional data would be amassed using Geographic Information System software. Key areas currently unmapped would be surveyed at sea and ground-truthed using appropriate visual and sampling techniques. GLACES will produce one of the largest integrated deep-water habitat mapping efforts and will greatly assist standardisation and habitat categorisation by working closely with existing schemes and government agencies. In addition to refining existing and developing new habitat maps, GLACES also incorporates the emerging science of predictive habitat mapping. Furthermore, dating fossil corals found during mapping surveys will enable researchers to produce 'habitat maps' of corals for the past, which in turn can be linked to ecological niches required for coral growth (i.e. for particular time periods or climatic and oceanographic conditions).

Oceanography & food supply: Understanding the hydrographical context of cold-water coral habitats is vital to study food supply mechanisms, near-bed sediment flux and larval transport. The importance of these issues places physical oceanography as a key overarching theme of GLACES. The programme aims to support studies addressing both local-scale physical characterisation of study sites alongside interpretation of larger-scale boundary currents, density horizons and internal wave dynamics.

Policy: The policy regime in which marine conservation measures are developed is complex and constantly evolving. For example, cold-water corals were among the 'vulnerable marine ecosystems' covered under UN General Assembly Resolution 61/ I 05 calling upon states to implement precautionary measures for the long-term conservation of High Seas habitats. As well as providing data on population connectivity towards marine protected area design, GLACES will contribute to the review and compilation of relevant information of maritime policy both at

national, European and international (High Seas) levels. The policy work will ensure clear two-way communication between the pure science projects and the policy-maker end users. Several social scientists are members of the existing TRACES community and their research will for example focus upon regional governance case studies to critically evaluate the process of conservation policy development for cold-water corals and deep-sea habitats in general. Once again, we aim to apply the approach developed through TRACES in an Atlantic context to the wider global ocean related to new initiatives such as the Global Ocean Biodiversity Initiative (GOBI, http://openoceansdeepseas.org/).

Timeliness

An international global cold-water coral programme is feasible now for a number of reasons: (1) baseline habitat mapping provides a database of target sites across key ocean basins such as the Atlantic, a global centre of cold-water coral records; (2) genetic markers (notably microsatellites) have recently been developed for a number of cold-water corals, allowing issues such as their genetic cOlli1ectivity and clonality to be examined; (3) geochemical advances have now produced coral skeletal proxies for parameters including ocean ventilation history, temperature, nutrient status and pollution; (4) seagoing infrastructure (e.g. remotely operated and autonomous underwater vehicles, coring and observation tools) and cold-water coral expertise have both expanded dramatically over the last decade.

Understanding deep-water, suspension-feeding systems, such as those formed by cold-water corals, requires integrated interdisciplinary research involving marine biologists, chemists, geologists and physicists. Developing appropriate tools for their long-term conservation not only requires understanding their ecological connectivity but also the policy context in which conservation strategies can further develop. Here social scientists and those working at the interface of science and policy are needed.

Our thematic approach meshes well with this year's SCOR focuses on marine geology, chemistry and palaeoecology, and the long term results will be important for:

- Identifying limitations to predictions in the future state of the ocean
- Climate related studies in preparation for the next IPCC assessment
- Interactions and mechanisms in abrupt climate change

International Approach

Research into cold-water coral ecology and palaeoceanography has in large part been restricted to exclusive economic zones with funding from either national or regional agencies. Research has also typically been driven by individual scientific disciplines with ecological work focussed on describing the diversity of life in these complex habitats and geochemical work focussed on developing accurate dating techniques and novel environmental proxies from coral carbonate. There is now a clear scientific community consensus that to advance our understanding of cold-

water coral ecology and realise the full potential of their palaeoceanographic archives we need to work in a unified, interdisciplinary manner at the scale of individual ocean basins and beyond. This consensus was exp lored through workshops and discussions over the last two years during the development of the Trans-Atlantic Coral Ecosystem Study. The TRACES initiative was launched in February 2008 and was followed by two scientific workshops in Wilmington NC (USA) and Faro (Portugal). These workshops attracted 85 participants from 14 countries who collectively discussed and prioritised the overall TRACES research agenda. Following these two workshops the TRACES Science Plan was prepared by a writing team where both European and North American researchers prepared each chapter. The writing team met at a Science Plan workshop (Woods Hole MA, USA) and the TRACES Science Plan and reports from the earlier workshops are available online (www.lophelia.org/traces).

With this work in place we successfully applied for a European Science Foundation EUROCORES programme and the EuroTRACES call for proposals was opened in January 2010 to researchers from Belgium, Germany, Ireland, Luxembourg, Netherlands, Poland, Portugal, Slovenia and Spain (see www.esf.org/eurotraces). EuroTRACES represents the first dedicated call to support TRACES research, but it is limited to these nine European countries.

To capitalise on the progress with TRACES and EuroTRACES, the GLACES Working Group will start work to develop the first truly international, global research programme on cold-water coral ecology and palaeoceanography. This Working Group will provide the international scientific oversight for this nascent programme. It will form the first Steering Committee responsible for co-ordinating activities, ensuring projects are correctly standardised and maintaining the programme's overall Science Plan. It will produce clear published guidelines and presentational materials summarising each science theme. The Group will keep close links with funding agencies and policy makers to create an international Advisory Board. Finally, it will organise international conference sessions in 2014 and 2015.

Terms of Reference

1. Identify representatives from funding and regulatory agencies to involve in Working Group activities and eventual formation of a GLACES International Advisory Board.
2. Produce and publish field-based guidelines for consistent sampling and reporting of samples and data required to be a GLACES-compliant research cruise.
3. Identify priority areas for research cruises and sampling across the global ocean and compile information on planned cruises.
4. Examine ways that TRACES may expand from its initial North Atlantic focus to become a global study of cold-water corals.
5. Organise international conference sessions at 5th International Symposium on Deep-sea Corals (Netherlands, 2012) and 12tl1 International Reef Symposium (Australia, 2012). Apply for special session at AAAS Annual Science Symposium in 2014 with professional assistance from the Communication Partnership for Science and the Sea (COMPASS) and

SeaWeb.

Proposed Meetings

- Spring 2011 Initial meeting (Edinburgh, UK) Video/phone conference at 6 months
- Second meeting during International Symposium on Deep-sea Corals (April 2012, The Netherlands)
- Video/phone conference at 18 months
- Final meeting (AAAS Science Symposium, USA, February 2014)

Working Group Members

1. Jess Adkins (USA) (co-chair) - palaeoceanography
2. Scott France (USA) - phylogenetics & deep-sea ecology
3. Norbert Frank (France) - palaeoceanography
4. Akihiro Kano (Japan) - palaeoceanography & deep-sea drilling
5. Alberto Lindner (Brazil) - genetics & biology
6. J. Murray Roberts (UK) (co-chair) - biology & ecology
7. Laura Robinson (UK) - palaeoceanography
8. Tim Shank (USA) - genetics & population connectivity
9. Ron Thresher (Australia) - palaeoceanography & ecology
10. Claudia Wienberg (Germany) - palaeoceanography & geology

Existing Support

Initial discussions with the European Science Foundation on how this working group could link to EuroTRACES networking activity have taken place. Members of this proposed working group are both partners and associated partners in currently proposed EuroTRACES projects.

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2-144

2.3.2 Beyond the Conveyor: Advancing Training and Research in ‘Palaeo Physical Oceanography’

Beyond the Conveyor: A Proposal for an inter-disciplinary SCOR Working to Advance Training and Research in 'Palaeo Physical Oceanography'

Abstract
The palaeoceanographic record is uniquely important for our understanding of the global climate system. Many insights into the special climatic role of the ocean circulation have come specifically from palaeoceanographic reconstructions that extend beyond historical observation. However, there remains a significant gap between modern oceanographic theory and the conceptual framework that underpins palaeoceanographic inference. This can limit the impact and relevance of palaeoceanographic findings, or even distort their interpretation. By bringing together a group of leading palaeoceanographers, fluid dynamicists and oceanographers, the proposed working group will begin the process of closing the gap between palaeoceanography and modern ocean physics.
The proposed working group will engage in two phases of action, to be carried out over the course of four years. The first phase will produce a document for peer-reviewed publication, providing: I) a review of recent developments in palaeoceanography, identifying where the conceptual premises of palaeoceanographic inference have yet to be harmonised with modern oceanographic theory; 2) a description of the most important research questions in palaeoceanography where the involvement of fluid dynamicists and physical oceanographers is likely to be essential; and 3) a description of research problems in physical oceanography that will benefit significantly from a uniquely 'geological' perspective. The second phase of work will involve direct engagement with researchers in both disciplines to develop identified research questions into funded projects and studentships. Three workshops will serve to bring the working group together for these phases of action and a dedicated web site will serve to inform members and interested parties of actions to be taken, deadlines and opportunities for collaboration or student exchange.
Our ultimate goal will be to identify and address the main challenges involved in reconciling our interpretation of the past with modern ocean physics. This will sharpen the focus of palaeoceanographic research, while at the same time broadening the impact and contemporary relevance of geological research into global climate change.

Rationale
Understanding the ocean circulation is crucial to understanding the climate system, including in particular its response to natural or anthropogenic perturbations. Predictions of the rate of atmospheric CO_2 rise and global warming rely to a large extent on accurate estimates of the thermal inertia of the ocean and its approach to chemical equilibrium with the atmosphere, both of which rely to a large extent on knowledge of the large-scale ocean circulation and its stability

under changing climatic conditions.
In order to understand how ocean and climate interact, we may employ fluid dynamical theory (in complex numerical models or simplified thought experiments), we may study empirical data (covering the last few decades), or we may look to the geological record. The last of these options is unique in allowing us to witness the behaviour of the ocean under conditions that differ significantly from today. In short, the geological record allows us to test our theories of ocean-climate interaction outside of the historical 'calibration sample'.
Currently there is a growing realisation of the potential that palaeoceanographic study holds for the advancement of our understanding of the climate system. At the same time, it has become clear that the special character of palaeoceanographic evidence (e.g. sparse geographical coverage, inherent chronological uncertainty, indirect 'proxy' observations) requires a special approach to its interpretation: arguably, one that has yet to become pervasive in the palaeoceanographic community. It is therefore particularly timely to set up a SCOR working group that will focus on closing the gap between the fundamental principles and methods of contemporary physical oceanography and those of the growing field of palaeoceanography. Indeed, the time for merely critically comparing palaeoceanographic and physical oceanographic methods has passed; it is time now to move the field of palaeoceanography forward, precisely so that it can contribute more incisively to the field of modern ocean Science.

A SCOR working group represents the ideal mechanism for achieving this goal. This is primarily because SCOR support: 1) admits and encourages cross-disciplinary membership, which will be essential to the proposed endeavour; 2) permits a broad international participation, which in our case will be important for building adequate momentum to move the field forward; 3) is not beholden to any government directive or national science base, but rather exists to serve the interests of ocean research in general; and 4) permits the establishment of a team with a sufficiently long-term (4 year) mandate to ensure that real progress can be made. In contrast, other (national or charity) support structures could not accommodate the necessary international (especially trans-Atlantic) participation, or ensure the sort of long-term support that this type of endeavour requires.

Scientific Background

Physical oceanographers and palaeoceanographers focus much of their attention on precisely the same phenomena (heat/material transports, deep western boundary currents, wind-driven upwelling, deep convection etc ...). However, the types of observations available and the analytical approaches adopted differ substantially in each field. The skills and approaches required in palaoeceanography and in physical oceanography are not completely commensurate, and could not usefully replace each other. Nevertheless, it is clear that the analysis and interpretation of palaeoceanographic data could benefit greatly from the specialist insights of fluid dynamics or the methodological approaches of physical oceanography. Similarly, the reconstruction of past ocean/climate states may provide a unique 'palaeo-laboratory' for the investigation of phenomena that have yet to find consensus in physical oceanography. Cross-

disciplinary research, with *'palaeo physical oceanography'* as its focus, has much to offer the fields of palaeoceanography and physical oceanography alike.

Twenty years ago, W. Broecker first described the large-scale ocean circulation system as *'The Great Ocean Conveyor'* (1). This pioneering metaphor has proven immensely influential and useful in ocean research. It condenses many important facts about the global overturning circulation, including the existence of localised regions of deep-water formation, the transport of water from the surface to the abyss and back again, and the fact that transports of water around the globe are highly connected and act to move a variety of climatically and biologically important chemical species both laterally and vertically. These important aspects of the overturning circulation, and the conveyor metaphor, have become explanatory pillars in many areas of palaeoclimatology. Thus for example, the role of the global overturning circulation in glacial-interglacial carbon cycle change or the role of the Atlantic meridional overturning circulation (AMOC) in past abrupt climate change, are often eXplained in the palaeoceanographic literature in terms of the 'strength' of the conveyor circulation (2-4). At times this may represent a form of shorthand, providing a parameterisation of a more specific aspect of the ocean circulation that cannot yet be inferred from the existing palaeoceanographic data. However, as palaeoceanographic data become more varied and more detailed, our ability to go beyond this type of explanation becomes warranted, or even necessary. In this case it is important to ensure that our interpretations are not limited to the scope of the explanatory metaphor that happens to be at our disposal.

It is widely recognized that the 'conveyor' metaphor, although an immensely useful schematic, does not capture some key aspects of the ocean circulation system, and is therefore inherently limited as an explanatory metaphor (5). For many palaeoceanographic research questions, for example concerning glacial-interglacial CO_2 change or abrupt climate variability, it is becoming increasingly apparent that an enhanced conceptual model of the ocean circulation is required if significant progress is to be made. For example, it is now clear that our interpretation of the past must admit a broad range of transport timescales and pathways in the ocean (5, 6), as well as the importance of deep-water source regions outside of the North Atlantic (7). It has also been suggested that in considering the role of the ocean circulation in past abrupt high-latitude climate change, disproportionate attention has been focused on the role of deep circulations, relative to upper ocean transports (8). Similar questions have been raised concerning the energy budget of the ocean, and the relative importance of thermohaline density gradients *versus* wind-driven momentum transfers or turbulent mixing for the maintenance of the deep ocean circulations (9). Indeed, one of the main blind spots of the conveyor paradigm is with regard to relatively small-scale turbulent mixing processes (e.g. internal gravity wave breaking) that are important for both material and energy transfers in the ocean interior. It is possible that such processes could prove to be crucially important for transitions between different ocean and climate states in the past.

All of the above refinements of the 'great ocean conveyor' metaphor are active areas of research in physical oceanography, but they are also of direct relevance to a number of key research questions in palaeoceanography. In order to advance both of these fields together, it will be

necessary to design research projects that specifically target 'post-conveyor' hypotheses, and that draw on cross-disciplinary expertise. This will require that new analytical (statistical, inverse, assimilation) methods be adapted specifically to palaeoceanographic datasets, which carry both drawbacks and significant advantages over contemporary observations. The interpretation of existing palaeoceanographic data will thus be improved, as will the design of future palaeoceanographic analysis programmes and the state of ocean research in general.

Statement of Work and Terms of Reference

The proposed working group will engage in two phases of action. The first phase of will:

1. ***Review recent key developments*** in palaeoceanography, and identify where the conceptual premises of palaeoceanographic inference have yet to be harmonised with modem oceanographic theory.
2. ***Identify the most important research questions in palaeoceanography,*** specifically where the involvement of fluid dynamicists and physical oceanographers is essential.
3. ***Identify key research problems in physical oceanography*** that will benefit specifically from' geological' observations.
4. ***Summarize the above findings for publication*** in a widely accessible scientific periodical.
5. ***Establish a web-based forum*** to facilitate the management of the working group's activities (e.g. by informing members ofrequired actions and deadlines) and to advertise opportunities for inter-disciplinary exchange via studentships or post-doctoral projects.

The second phase of work will involve direct engagement with researchers in both disciplines to develop the research questions identified previously into nationally/internationally funded projects and studentships.

In order to meet these terms of reference, the working group will need to meet at least three times. Prior to the first meeting, informal gatherings of working group members will be convened at the 2010 AGU Fall Meeting (San Francisco, USA) and again at the 2011 European Geosciences Meeting (Vienna, Austria). These informal meetings will serve to lay the groundwork and clarify the agenda for the first formal meeting. The first formal meeting is proposed for the autumn of 2011, and will serve to accomplish the bulk of the first phase of work, in preparation for the writing of the preliminary 'summary/recommendation' report. The second meeting will take place one year later in 2012, and will involve a sub-set of the working group membership. This second meeting will have as its aim the finalisation of the summary/recommendation report for publication. The third and final meeting will take place two years later in 2014, and will take the form of an open science meeting. Funding for this meeting will be sought independently, through the European Science Foundation (ESF) or the Royal Society (UK) for example. The goal of this final meeting will be to share the working group's activities and momentum with the wider ocean research community.

It is intended that the working group proposed here will build upon two preceding SCOR

working groups in particular: the IAPSO/SCOR WG 121 on Ocean Mixing (chaired by R. Muench), and the SCOR/IMAGES WG 123 on Reconstruction of Past Ocean Circulation (PACE; chaired by 1. Lynch-Stieglitz). In order to ensure synergies between these working groups and their outputs we have nominated members/associate members who have been closely involved in WG 121 and WG 123. Whereas these previous working groups have engaged in detailed reviews within their respective fields (palaeoceanography and physical oceanography), our proposed working group aims, in effect, to bring their findings together to motivate new and incisive research at the juncture of these two disciplines.

Working Group Membership

Membership of the proposed working group should be internationally inclusive and with roughly equal participation ofpalaeoceanographers (P in the list below) and physical oceanographers (or fluid dynamicists, numerical modellers, statisticians; **O** in the list below). It is proposed that the group be chaired by an early career research scientist who will be able to direct the working group's activities without dominating its discussions. A chair and a co-chair are nominated below, representing each of the main research fields. The chair of the group will be responsible for convening the meetings and drawing up the draft reports. The working group membership proposed below is provisional and it is expected that a final list of participants will be obtained through consultation with the SCOR steering committee.

Proposed Full Members

1. Luke Skinner (chair)	GB (P; deep-water temperature/radiocarbon)
2. Peter Huybers (co-chair)	USA (O; state estimation inverse methods)
3. Eric Galbraith	CAN (P; biogeochemical cycling)
4. Helen Johnson	GB (O; AMOC stability and theory)
5. Francois Primeau	USA (O; transit time/pathway distribution methods)
6. Benedicte Lemieux-Dudon	France (O; Bayesian statistics, chronology modelling)
7. Trond Dokken	Norway (P; North Altantic water properties)
8. Stefan Mulitza	Germany (P; East Atlantic properties, global database)
9. Cristiano Chiessi	Brazil (P; South Atlantic water properties) Asia/Pacific region (O/P)
10. (To be named)	

Proposed Associate Members

Olivier Marchal	USA (O; state estimation techniques)
Axel Timmermann	USA (O; palaeoclimate modelling)
Carl Wunsch	USA (O; inverse methods, modem hydrography)
Michael McIntyre	GB (O; fluid dynamical theory)
Jean Lynch-Stieglitz	USA (P; stable isotopes, palaeo-densities)
Jody Klymak	CAN (O; turbulent mixing processes)
*Chris Garret	CAN (O; turbulent mixing processes)

Jess Adkins USA (P; global water properties, ventilation timescales)
Andy Watson GB (O; Southern Ocean mixing processes)
**Chris Garret* is *proposed as a link with the IAPSO/SCOR WG* 121 *on Ocean Mixing, though this link might also be provided by Jody Klymak.*

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2-150

2.3.3 Organic Ligands – The Key Control on Trace Metal Biogeochemistry in the Ocean

Proposal for a SCOR Working Group: Organic Ligands - The Key Control on Trace Metal Biogeochemistry in the Ocean

Abstract

The trace metals iron (Fe), copper (Cu), nickel (Ni), cobalt (Co), cadmium (Cd) and zinc (Zn) are essential micronutrients to marine phytoplankton and control primary productivity in up to half of the open ocean from tropical to polar regions. Consequently, they exert a major influence on the global carbon cycle and playa key role in controlling the world's climate. However, the availability of these metals to the biota is governed by speciation, whereby trace metals are bound by organic ligands. Organic ligands are defined as molecules that can bind to and form a complex with trace metals. In the ocean trace metals are overwhelming bound (90 to 99.999%) to organic ligands. Metal-binding ligands are ubiquitous in the ocean yet the composition and source of these ligands remains largely unknown. Over the past three decades, advances in analytical techniques have led to consensus on accuracy and precision, and dramatically improved our knowledge on the global and regional distributions of trace metals. In contrast, our understanding of trace metal-binding ligands and their pivotal biogeochemical functions remains at a comparatively early stage. *To date, we do not know the exact composition, source and provenance of metal-binding ligands, which is hindering further advances in the field of trace metal biogeochemistry.*

The proposed working group would focus on advancing our understanding of trace metal-binding organic ligands in the oceans, and over a 4-year period the group will (1) summarize published results and generate a ligand database to confirm the nature of the most pressing research questions; (2) establish a ligand intercalibration programme, and evaluate key analytical issues with currently employed methodologies to establish whether they need to be improved, supplemented or eventually replaced; (3) debate the nature of sampling strategies for both laboratory and field experiments that are needed to enhance our understanding of the links between the provenance, fate, distribution, chemistry and biological function ofligands; (4) recommend future approaches to ligand biogeochemistry including the decade-long GEOTRACES field efforts (i.e. both regional surveys and process studies) and the need for rapid incorporation of this research into biogeochemical models. In addition, the working group will also establish a ligand biogeochemistry webpage and promote this forum for discussion of ideas and results by our members soliciting input from both the trace metal and modelling communities. This interdisciplinary webpage will provide a platform to propose special sessions on trace metal-binding ligands at international meetings such as Ocean Sciences and EGU.

Rationale

Understanding the role of metal-binding ligands in oceanic biogeochemistry is extremely important, as these ligands control the bioavailability of trace metals, thus influencing global elemental cycles such as carbon and nitrogen. To a large extent, we simply do not understand the role or chemical structure of metal-binding ligands in the oceans and we cannot, therefore, predict how they, and hence trace metal cycles, will respond to projected global alteration of continental aridity (dust supply), ocean acidification, and oceanic oxygen minimum zones due to a changing climate.

It is timely to focus on the issue of trace metal-binding ligands as it is now more than a decade since 'The Biogeochemistry of Fe' (SCOR WG 109) was established, which led to a seminal publication on iron biogeochemistry that concluded with key questions for future research. This resulted in dramatic advances in analytical capability (e.g. production of an iron standard) and quantification of iron sources and sinks. However, a key question relating to the composition, source and biological role of metal-binding ligands has yet to be addressed and is the focus of this proposal. In addition, a SCOR-sponsored international programme, GEOTRACES, was launched in late 2009. The decade-long GEOTRACES programme aims to determine the distributions of trace metals using ocean section cruises through all ocean basins. A core measurement on these sections is metal-binding ligands. Knowledge of metal-binding ligands is essential to understand their control on trace metal bioavaiiability and phytoplankton growth in the ocean. Furthermore, as these ligands are inextricably linked to trace metal cycling, it is critical to determine how best to incorporate metal-ligands with trace metal data in global ocean models. For example, results from models of Fe biogeochemistry fluctuate dramatically depending upon the ligand data chosen (Parekh *et al. 2005).* Therefore, to ensure that GEOTRACES benefits from understanding the role of metal-binding Iigands, it is important that this SCOR WG is established as soon as possible, to both better help in interpretation of data on trace metals and ligands and to inform sampling and analytical strategies. This will also allow us to target a GEOTRACES process study designed to study ligand dynamics at a site that may be used as a natural laboratory.

Given the need for a multidisciplinary solution to this problem, a SCOR working group, consisting of analytical chemists, biogeochemists, and modelers is the best mechanism to focus the international scientific expertise on metal-binding ligands. Appropriate scientific expertise will be assembled from different countries and an international working group will help develop this topic in developing nations. Other organizations cannot ensure that the activity is suitably interdisciplinary, involve scientists from a wide range of countries, while helping train young scientists. The results of this WG will be presented during a symposium and published in a special issue of a journal or book and a report to SCOR.

2-152

Background

A short background is provided here to summarize the issues that have motivated us to propose a working group on metal-binding ligands.

In the decade since the seminal publication from the SCOR WG on 'The Biogeochemistry of Fe' (Turner & Hunter 2001), and the inextricable links between Fe and Fe-binding ligands presented in that book, there has been a considerable increase in publications focusing on Fe speciation as well as those for other trace metals, albeit to a lesser extent. It appears that Fe, Cu, Ni, Co, Cd and Zn are all bound to various extents by organic ligands and these metal-binding ligands are ubiquitous in the ocean. Metal-binding ligands appear to facilitate bioavailability and uptake of the trace metals Fe and Co, while those binding Cu, Ni, Cd and Zn sequester and decrease the bioavailability. While there are some known biological sources of metal-binding ligands, such as for Fe and Cu, the sources and identities of most ligands remain unknown.

At present we indirectly measure the binding capacity (i.e., the ligand concentration and binding strength, termed *stability constant)* of the metal of interest by means of a metal-ligand titration with electrochemical detection (e.g. Croot & Johansson 2000). Most ligand data published to date either describes the distribution of ligands binding to a specific trace metal in a specific water mass, or characterizes the ligand produced by one specific organism grown in a laboratory culture. Only recently, and supported through analytical advances, research has focused on determining the link between the binding strength of ligands in natural seawater and the biota that may be producing the metal-complexing ligands. For example, siderophores, produced by bacteria for iron acquisition have been shown to have similar stability constants as Fe-binding ligands in surface waters and have been measured in seawater (Mawji *et al.* 2008). While most focus has been on Fe, and to some extent on Cu, very little is known about the composition and sources of other essential trace metal-binding ligands. What is known is that metal-binding Iigands are typically present everywhere in the water column for many elements, suggesting that they are either highly recalcitrant, and/or a result of passive biological production *in-situ* (i.e., remineralization). For example, the bioremineralization of sinking particles was shown to produce iron-binding ligands (Boyd *et al.* 2010), humic substances can bind Fe and may be the source of some Fe-binding ligands in the deep ocean (Lageria & van den Berg, 2009), while zooplankton grazing on phytoplankton also releases Fe-binding ligands (Sato *et al.* 2007). In addition, hydrothermal input of organic Iigands to the deep ocean may be much larger than previously thought (Sander *et al.* 2007) and has only just been incorporated into models (Tagliabue *et al.* 2010). Further, the ubiquitous presence of metal-binding ligands would seem to indicate that at least some of these ligands are not metal-specific. While this has not been directly assessed to date in the field, compiling published data would allow some insights into this issue. This is crucial as recent evidence suggests that Fe availability depends on Cu availability (Peers *et at.* 2005), with the bioavailability of both metals governed by organic complexation; similar synergistic behavior between other trace metals may also be important. Thus, an over-arching question is: *What is the composition, source and fate of metal-binding ligands?*

Currently, in the absence of structural characterization of the ligands, conditional stability constants provide the only means to distinguish between different metal-ligand complexes in the ocean. Measured metalbinding ligands are typically reported in terms ofligand classes, with Ll used for stronger ligands and L_2 for weaker ligands. The distinction between these ligand classes has proven useful in discussions of sources and roles of these ligands, but the distinction remains an operational definition that varies between analysts and is strongly dependent on the method used and hence the analytical window applied. Therefore, we need to investigate the distinction between Ll and L_2 ligands and *Determine how to best define these ligand classes.* In addition, intercalibration studies have just started for Fe and Cu-binding ligands and need to be completed for the remaining trace metals. The data acquired using ligand titrations needs to be intercompared and examined in detail to ensure that the numbers for the concentration [L] and stability constants (log K') of measured ligands are valid.

At present, the size fractionation of trace elements is operationally defined by filtration whereby the colloidal fraction is typically 0.2-0.02 /lm while the truly soluble is < 0.02 */lm.* Studies for Fe have shown that Fe-binding ligands are predominantly present in the colloidal fraction and that this size range is critical to understanding the variability in dissolved Fe (Bergquist *et at.* 2007). Does this imply that colloidal ligands are more easily scavenged than those in the soluble fraction? The proposed working group will use available speciation data and combined knowledge of the technique to *Evaluate to what extent the distributions of metals and those of metal-bin ding ligands are correlated in the oceans.* Assessing the available data from this perspective will allow additional insight into ligand sources and functions, as well as a framework for incorporating metal-binding ligands into models.
Modelling trace metal distributions is a formidable task at present. A good example is provided by recent attempts to model the Fe cycle where models have to make broad assumptions because of poor knowledge about the speciation of Fe (Boyd *et at.* 2010). Even less is known about the speciation of other trace metals in the oceans, and these are typically left out of models despite their importance in phytoplankton growth. Thus, a primary goal of the proposed working group is to *Assess how to incorporate metal-binding ligands into biogeochemical models.* Modellers require knowledge not only on the distribution of metal-binding ligands but also on the speed of reactions between trace metals and these ligands. Both the database and the interactive webpage will help address this issue.

Statement of Work/Terms of Reference

1. To summarize published results on all aspects of metal-binding ligands in the oceans (i.e. distributions, chemical structure, sources, sinks, stability), and generate an organic ligand database for use in biogeochemical models and for those working in the field (including results from ongoing GEOTRACES, SOLAS and CLIV AR efforts).
2. To critically evaluate key analytical issues with currently employed methodologies to establish whether they need to be improved, supplemented or eventually replaced.

3. To debate the nature of sampling strategies for both laboratory and field experiments that are needed to enhance our understanding of the links between the provenance, fate, distribution, and chemistry and biological functions of these organic metal-binding ligands in the oceans.
4. To recommend future approaches to ligand biogeochemistry including ongoing GEOTRACES field efforts (i.e., both regional surveys and process studies).
5. To produce information/material resulting from the outcome of the above points in the form of Website, journal special issue or book and a report to SCOR.

MEETINGS, WORKSHOPS AND SYMPOSIA:

It is proposed that the first formal meeting of this WG will take place before the Aquatic Sciences Meeting in San Juan, Puerto Rico (Feb. 13-18, **2011).** Preliminary communications leading up to this meeting will take place during the preceding year and will lead to identification of additional Associate Members, fine-tuning of the Terms of Reference, and creation of an agenda. During the meeting the WG will set up intercalibration efforts and start work on the format for the database and webpage, which will also act as a forum for information exchange and details of new meetings. Other funding sources for the intercalibration efforts, the workshop and final publication will be determined.

Approximately one year after the first meeting a second meeting and an international workshop on trace metal-binding ligands in seawater will be held. This will allow a nominal one-year period over which to structure the workshop agenda, issue announcements and invitations, secure needed funds, and make other necessary preparations. To keep costs at a minimum this would be in combination with the Ocean Sciences Meeting in Salt Lake City, Utah, USA (Feb. 19-24,2012) The workshop will provide the opportunity for all Full and Associate members of the WG to discuss all points of the terms of references. Groups will be formed and tasks assigned to work on projects and prepare material to be presented at the special symposia and in the special issue or separate book.

Full members of the WG will meet again in year 3 to determine the progress made by different groups and discuss necessary actions to successfully present at a dedicated symposium in year 4 during the Ocean Science meeting in 2014. That conference would also set the date for the fourth and final meeting during which the WG will be rounding off the results and outcomes and finalize the publications. Separate funding will be sought from EU-GEOTRACES COST Action and other sources for the WG third meeting Place and exact time for this meeting will be decided on but could again be in combination with the Aquatic Sciences Meeting 2013.

Working Group Membership

The final working group membership is proposed to consist of 10 specialists:

Name	Affiliation	Specialty within the field of trace metal speciation in seawater
Kristen Buck (proposed co-chair)	Bermuda Institute of Ocean Sciences, Bermuda	Organic complexation, expert in methods, bioavailability of trace metals
Maeve Lohan (proposed co-chair)	University of Plymouth, United Kingdom	Organic complexation, expert in methods, Flow injection analysis
Sylvia Sander (proposed co-chair)	University of Otago, New Zealand	Organic complexation, expert in methods, mass spectrometric hydrothermal systems.
Alessandro Tagliabue	Laboratiore de Science du et de l'Environment, France	Models of ocean biogeochemistry
Kathy Barbeau	Scripps Institution of Oceanography, USA	Bioavailability and reactivity of species,
Peter Croot	Chemische Ozeanographie Kie!, Germany	Organic complexation, expert in methods, bioavailability of trace metals
Martha Gledhill	National Oceanography Centre, Southampton, United Kingdom	Mass spectrometric determination of Seawater.
Shigenobu Takeda	University of Tokyo, Japan	Interaction between biological processes and trace metal
Michael Ellwood	ANU Canberra, Australia	Organic complexation, expert in methods and ICP-MS
Rujun Yang	College of Chemistry, Ocean University of China, China	Organic complexation, metal humics

Corresponding members

Constant van den Berg (UK), James Moffett (USA), Phil Boyd (NZ), Francois Morel (USA), Barara Sulzenberger (CH), Ken Bruland (USA), Keith Hunter (NZ), Mak Saito (USA), Loes Gerringa (NL).

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International

11 June, 2010

Executive Committee
Scientific Committee on Oceanic Research

Greetings,

We are writing to support the proposal to form a SCOR working group on metal-binding organic ligands. Such a working group has potential to add substantially to our knowledge of the factors that regulate the supply of essential micronutrints to marine organisms as well as the implications for marine ecosystems. The objectives of this working group nicely complement those of the GEOTRACES program.

GEOTRACES aims to identify the processes that supply trace elements to the ocean and to quantify the rates of trace element removal. In addition, GEOTRACES will characterize the internal cycling of trace elements by biological uptake, chemical scavenging, and physical transport. These goals will be achieved in large part by measuring the distribution of trace elements throughout the ocean.

Chemical speciation of trace elements, often dominated by organic complexes, influences both the bioavailability of the elements and their residence time in the ocean. This is particularly important for micronutrient elements, such as Fe, Co and Zn, which are thought to regulate the growth of certain organisms. GEOTRACES cruises offer an opportunity to examine the chemical speciation of trace elements, and its variability throughout the ocean. However, a detailed investigation of the composition, structure and origin of organic ligands is beyond the scope of the program. Similarly, GEOTRACES lacks the resources to mount a comprehensive evaluation of competing technologies for investigating ligands. Consequently, the proposed working group would add value to GEOTRACES by recommending best-practice strategies to investigate organic ligands in seawater. Once identified, these technologies can be applied routinely aboard GEOTRACES expeditions.

Sincerely,

Robert Anderson and Gideon Henderson
Co-Chairs, GEOTRACES SSC

• ROBERT F. ANDERSON AND GIDEON HENDERSON, CO-CHAIRS•
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2.3.4 Modern Planktic Foraminifera and Ocean Changes

Proposal for a SCOR Working Group on Modern Planktic Foraminifera and Ocean Changes

Abstract

Planktic foraminifera are arguably the most important carriers of paleoclimate information available to scientists. Our ability to reconstruct past climate states and to predict the impact of the functioning of foraminifera under changing oceanic conditions in the future depends on a complete understanding oftheir ecology, biology, physiology and the mechanisms by which they incorporate geochemical tracers for reconstructing oceanic temperature, pH and salinity. The last synthesis of the state-of-the-art on planktic foraminifer was published 20 years ago (Hemleben et aI., 1989). Since then, a suite of new technologies and experimental methods have been applied to living and fossil foraminifera that have resulted in new biological and ecological insights on this group. The result has been an expanded context and a wealth of novel ways to data mine the thousands of publications that exist in the literature. The here proposed synthesis of knowledge and techniques will be a 21 5t century keystone that both articulates and focuses future research needs and potentials. The WG will disseminate the current knowledge of this field to active researchers, students, specialists and other users of foraminiferal data, from the fields of the marine carbon cycle, through paleoclimate reconstructions to model predictions of future climate change.

Rationale

Planktic foraminifera are the major source of proxy information for reconstructing past changes in ocean biological, chemical and physical parameters. Species assemblages and the geochemical composition of shell calcite provide much of the primary paleoenvironmental information used to reconstruct past oceanic temperature, salinity, productivity and changes in the atmospheric hydrological system. These proxies are commonly based on observed correlations between an environmental parameter in the modem ocean and the geochemical or assemblage distribution data from recent ocean sediments. However, understanding such empirical relationships at the bio-physico-chemical level, and quantification ofthe relevant ecological components influencing a signal are generally not sufficient for an optimal application of the parameter-proxy relationships. An integrated understanding of these processes is necessary for correctly quantifying past ocean physico-chemistry and determining the effect of ongoing ocean change in terms of thermohaline circulation and ocean acidification on the calcification of these organisms.

Given the large amount of recent research, the lack of any synthetic work for two decades and the upcoming significant generation shift, we believe it is time to integrate the broad knowledge from different (bio-physico-chemical) disciplines, which relate to modem planktic foraminifera. They include 1) their spatial and temporal distribution in the world ocean, 2) their calcification mechanisms, 3) the biological and chemical controls on their shell chemistry and 4) their eco-

phenotypical and genotypical variability. Experts on plankic foraminiferal ecology, biology and chemistry often work on an individual basis and interact and collaborate occasionally, but have not yet fully integrated to address the fundamental issues in this research area in a coordinated way. The proposed working group would provide a mechanism to make this happen as well as to provide a platform to involve young scientists as well as researchers from developing countries.

Results from this working group should stimulate active scientific networking, especially for engaging younger scientists, as well as produce future research proposals and projects. The WG will profit from national and international research programmes (e.g. the EU FP7) and the projects of its members and in turn will provide an umbrella for international research efforts that include the sharing of novel ideas and research tools for future planktic foraminiferal analyses and data interpretation. Cooperation with IGBP PAGES has been initiated to establish a joint SCOR/IGBP WG. The WG will also be open for, and actively stimulate cooperation with, related international scientific initiatives in which the proposed members of the group are actively involved.

Scientific Background

Below, we summarize the primary issues that have prompted the involved scientists to propose this WG.

The usefulness of planktic foraminifera for reconstructions of the ocean's climate were recognized in the late 1940's with Urey's seminal papers (Urey, 1947; Urey, 1948) on oxygen isotopes in nature, and subsequent publications by his student, Cesare Emiliani, (Emiliani, 1954; Emiliani, 1955a; Emiliani, 1955b) on planktic foraminifera geochemistry and Pleistocene Temperatures. Following the recognition of their potential as providers of information on the state of past oceans and climate, the species concept for living planktic foraminifera has been standardised in the 1960's (Parker, 1962), allowing detailed mapping of species abundances in the plankton and surface sediments of the ocean. This work has led to descriptions of the physico-chemical properties of the habitat of individual species and their specific ecological demands governing the geographical distribution of the various species and their abundance (Be and Hamlin, 1967; Be 1977) and facilitated their first large-scale applications in the reconstruction of the ocean's temperatures during the last glacial period (CLIMAP 1976).

Since then, foraminifera are used as a primary carrier of geochemical information on past environments and their fossils from marine sediment archives have been used to quantify past ocean conditions related to oceanic temperature, salinity, ocean stratification, atmospheric CO_2 concentration and biological productivity back to about ~ 120 million years ago. Detailed studies ofthe modern spatial and seasonal distribution of foraminifera in the world's oceans (Be, 1977; Be et aI., 1973; Be et aI., 1971; Deuser, 1987; Deuser et aI., 1981; Tolderlund and Be, 1971) and early culture studies followed (Anderson and Be, 1976; Be, 1980; Be et aI., 1977; Hemleben, 1982; Spindler et aI., 1978; Spindler et aI., 1979), which provided fundamental information ranging from the ecological preferences of species to the individual's life cycle and calcification. Since the

comprehensive review of Hemleben et al. (1989), a vast and diverse amount of new data has been collected, highlighted by more than 10000 papers in the Web of Knowledge with 'foraminifer' in the title or abstract. This information has not been synthesized to date and hence is not available to nonspecialist scientists in an accessible form.

Today, the quantification of past ocean properties is based on either the distribution of species and their abundances or the geochemical (trace elemental and stable isotope) composition of the calcareous shells. Although in recent years, multiple geochemical tools have been combined to reconstruct parameters such as ocean salinity (Lea et aI., 2000; Schmidt et aI., 2004; Schmidt et aI., 2006), uncertainties in the physical, chemical and biological controls on these proxies place limits on their applicability to paleoclimatic problems (Rohling, 2000). Furthermore, cryptic speciation (Kucera and Darling, 2002), morphological variability (; Kennett, J.P., 1976, Steinke, S., et ai, 2005)), diagenetic overprinting (Groeneveld et aI., 2008) and incomplete knowledge ofthe timing and cellular mechanisms controlling shell calcification across the different species-specific habitat depths introduce poorly constrained uncertainties in paleoceanograhic reconstructions.

It is also important to broaden our knowledge of uncommonly used foraminifera species (Le. deep-dwelling forms, specialists for certain ecological niches, rare species), which have not been studied in detail nor used in paleoceanographic studies, as these species might provide novel information about the ocean's interior processes. The first modeling experiments to predict the global distribution of planktic foraminifera and their seasonal distribution and productivity (Fraile et aI., 2009a,b, Lombard et aI., 2009) represent a promising avenue of research to understand the relationship between the tolerance ranges of species and the highly inter-related environmental parameters oftheir oceanic niches (Schiebel and Hemleben, 2005). Although the physiological basis for calcification in foraminifera is being revealed in a number of recent papers (Erez, 2003; Bentov and Erez, 2005; De Nooijer et aI., 2009), most of these studies have been conducted with benthic species. Translation of approaches, methods and models to planktic species has the potential to quantify the biological effects on trace elemental incorporation and isotope fractionation (the so--called 'vital effect'). Investigations of molecular genetic diversity in planktic foraminifera continue to reveal fascinating insights into the cryptic diversity in this group (Darling et aI., 2007), its relationship to morphological variability (Morard et aI., 2009) and the possible underlying biological processes (Aurahs et aI., 2009).

To fill the gaps in our knowledge and understanding of these organisms is an important and urgent challenge in the light of ongoing ocean acidification and ocean warming. There is evidence for reduced calcification since the start of the industrialization (Moy et aI., 2009, de Moel et aI., 2009) by about 30% and clear shifts in assemblage composition have been observed in pace with the warming trends of the last 150 years (Field et aI., 2006). Will these organisms go extinct as a result of increasing ocean acidification and how will their distribution change as a result of temperature changes?

Until now, individual lines of research have been pursued largely independently and a coordinated action, summarizing the consequences ofthis knowledge for the further applications, is missing. This is most unfortunate as the paleoclimate community increasingly appreciates the potential of climate reconstructions based on these organisms (Ivanova, 2009) to further improve climate models. The situation is further aggravated by the multitude of disciplines involved in the studies of these organisms, and it is a prerequisite that the various communities "speak the same language" to facilitate future cooperation. The proposed working group will therefore contribute not only to a synthesis of knowledge on planktic foraminifera, but it will set standards and benchmarks in their taxonomy and ecology, in an accessible way for a range of disciplines.

Terms of Reference

The main goal of the proposed WG is to synthesize the existing knowledge of modern planktic foraminifera, to build on this knowledge for identifying priority research and to transfer expertise to the generation of young researchers.

The proposed working group will:

1. Synthesize the state of the science of modern planktic foraminifera, from pioneering to ongoing research including
   - their spatial and temporal distribution in the world ocean
   - their calcification mechanisms and shell chemistry
   - and their eco-phenotypical and genotypical variability

as a peer-reviewed publication in an open-access journal (deliverable 1).

2. Provide guidelines (cookbooks) in terms of species identification, experimental setup for culture studies, laboratory treatment prior to geochemical analysis (deliverable 2) and identify existing gaps in the available knowledge in order to direct future research.
3. Establish an active Web-based network in cooperation with ongoing (inter)national research programmes and projects to guarantee an open-access world-wide dissemination of results, data and research plans (deliverable 3).
4. Document the work of the group in a special issue of an open-access journal (deliverable 5) in connection with a specialized symposium with emphasis on modern ocean change i.e. thermohaline circulation and ocean acidification, during one of the AGU or EGU conferences, ideally held at the joint EGU/AGU meeting (envisaged for 2013 or 2014, deliverable 4).

Full Members:

1. Co-chair: Gerald Ganssen (proxies), The Netherlands
2. Co-chair: Michal Kucera (ecology and diversity), Germany
3. Jelle Bijma (ecology), Germany
4. Jonathan Erez (calcification), Israel
5. Richard Zeebe (bio-physico-chemistry), USA
6. Howard Spero (bio-geochem-paleo- experiments and culturing), USA

7. Dirk Kroon (micropaleontology), UK
8. Divakar Naidu (assemblages), India
9. Daniela Schmidt (microstructure), UK
10. Elena Ivanova (paleo applications), Russia

Associate Members:

1. Frank Peeters (spatio-temporal distribution), The Netherlands
2. Stefan Mulitza (proxies), Germany
3. Michael Schulz (ecological modeling), Germany
4. Thorsten Kiefer (PAGES), Switzerland
5. Caroline Cleroux (deep dwelling species), USA/France, Y
6. Ralf Schiebel (size/weight), France
7. Lennart de Nooijer (calcification), The Netherlands, Y
8. Steve Eggins (micro geochemistry), Australia
9. Kate Darling (genotypes), UK
10. Baerbel Hoenisch (bio-chemico-physics), USA, Y
11. Zhimin Jian (micropaleontology), China

Y= younger than about 35 years and at the postdoc level

Working Group Activities

If approved, the working group will organize its kick-off (Meeting 1) in early to mid 2011, potentially as a splinter meeting of a large international conference. Alternatively it can be connected to a foraminifera culturing workshop at the Wrigley Institute of Marine Sciences on Catalina Island in late July/early August 2011 held by Howard Spero. This would include a hands-on one week culture training course for a select group of grad students/post-docs prior to the workshop. During this meeting WG group members will

- present their expertise with short presentations
- set up the roadmap for science activities within the WG in detail following the terms of reference, assigning different WG members to lead on each term of reference
- define and distribute tasks for the writing of the overview publications with topics and deadlines for submission to the lead author(s)
- initiate and set up the Web-based networking and Web page (including an "electronic" atlas with photographs and detailed description of modern species)

Meeting 2 would be held in late 2012 or early 2013 to

- finalize the overview publication for submission during or shortly after the meeting
- finalize and make the Website available to the community and activate network
- launch network into its active phase
- conduct planning ofthe specialized symposium for 2014.

Meeting 3 would be envisaged for spring 2014 in conjunction with (potentially) the EGU/ AGU

joint spring meeting. During this session, the latest results ofthe WG members and associates will be presented. The meeting will be open, inviting contributions from non-members and closely related research with special emphasis on 'ocean acidification'. A contribution to the special issues of the open-access journal *Biogeosciences* (preferably) is obligatory for members and invited for other participants of the symposium.

The overarching philosophy of the WG is the active knowledge transfer from highly experienced experts to the younger scientists, supported by modern communication media.

Additional funding will be requested from organisations like AGU, EGU and (indirectly) from active research programmes. The work of the WG has strong affiliation with ongoing global ocean programmes like GEOTRACES, the FP7 program EPOCA and others and links with such programs will ensure dissemination of the activities and results via links to these activities.

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2.3.5 Biodiversity Patterns of the South Atlantic Mid-Ocean Ridge

Proposal of a New SCOR Working Group

1. Title: Biodiversity Patterns of the South Atlantic Mid-Ocean Ridge

2. Background and Rationale

The deep sea is the largest continuous ecosystem of the planet, but is also the least explored and understood. The traditional perception was that it is comprised of vast, remote, life-poor, and stable environments, which are isolated from other ecosystems and not affected by global-scale changes. Yet efforts to understand the patterns of life in the deep oceanic waters have revealed that the deep sea can be diverse, productive, and dynamically linked to the sunlit levels of the water column. These vertical interactions not only seem to determine localized concentrations of deep fish stocks, increasingly targeted by the fishing industry, but may also influence distribution of surface predators including tunas and whales. More importantly, studies have also demonstrated that life in the deep ocean is vulnerable to the effects of climate change and human economic activities including fishing. The more that is learnt from this remote ecosystem, the greater is the need to further describe it, understand it, and observe it for future changes.

The Census of Marine Life - MAR-ECO project has investigated ecological patterns of the deep sea by combining modern technology, an intensive and well-planned sampling strategy, and the collaborative work of international scientific expertise. Over the North Atlantic midoceanic ridge system, pelagic and benthic habitats to a maximum of 3500 m were sampled by capture gears, acoustic and optical devices, and tracked by satellite transmitters. Sampling was conducted either continuously along the ship's track or at predetermined points, as for instance, by moored upward looking sonars. As promising as the MAR-ECO approach was to enhance understanding of the deep sea, an additional challenge is to expand investigations to other deep areas of the planet, particularly in the overlooked southern hemisphere.

A MAR-ECO spin-off project is taking this challenge to the South Atlantic where deep life has been highly undersampled. The South Atlantic Ocean is the newest of all major oceans, formed by the separation of South America and Africa 175 - 90 million years ago, and is the only ocean basin to be directly connected to all of them. It is also economically important as it sustains a large portion of the Atlantic pelagic (i.e. tropical tunas) and seamount fisheries. Despite its size and role in the world ocean ecosystem, our knowledge of aquatic organism deep-water diversity and distribution is scarce and mostly inferred by comparison with the north Atlantic. The South Atlantic MAR-ECO project was set out to develop a strategy, based on the MAR BCO approach, to establish a biota sampling program, spanning from microorganisms to whales, capable of (a) increasing data on South Atlantic deep pelagic and benthic diversity and distribution, and (b)

integrating South American and African communities in the challenge of understanding the deep waters between them, identifying fishing opportunities and needs for conservation.

After a three-year planning phase (2007 - 2009) a first field effort took place in November 2009 on board of the R/V Akademik Ioffe and through a collaborative effort of the Shirshov Institute of Oceanology, Russia. During a 34-day cruise from Gran Canaria Island (Spain) to Cape Town (South Africa), a team of scientists from Brazil, Uruguay, Russia and New Zealand conducted a total of 63 pelagic and benthic sampling events up to 4.7 km deep over predetermined areas of the southern Mid-Atlantic Ridge and the Walvis Ridge. Results are still preliminary and a considerable effort is still required to process all biological samples. However partial figures point at approximately 1000 records of organisms included in 175 fish taxa, 44 cephalopods and over 200 benthic invertebrates (Ascidiacea, Anellida, Porifera, Crustacea, Mollusca and other groups). Additional plankton diversity data shall result from collaboration with the Trans-Atlantic Commission I (DHN - Brazilian Navy) conducted by the Brazilian R/V Cruzeiro do SuI in the same period.

Summarizing, discussing and publishing the patterns of diversity and distribution revealed by this first field effort are important next steps to be taken by the SA MAR-ECO international science team. Exploring new opportunities for field work in the future is also a critical task. These actions have been conducted under the Census of Marine Life agenda and chiefly supported by the A.P. Sloan Foundation. As this initiative will come to an end in 2010, SCOR is seen as an adequate environment for continuation of the required international collaborative work. A Working Group under SCOR would allow all involved PIs to be concentrated around the aforementioned tasks and also provide a suitable framework for interactions with international activities. Until now these have included (a) the CoML deep-sea field projects such as CenSeam (A Global Census of Seamounts), (b) Brazilian large-scale oceanographic programs such as Trans-Atlantic Commission I (DHN - Brazilian Navy), (c) regional fisheries organizations principally SEAFO (Southeast Atlantic Fisheries Organization) and (d) other deep-sea projects such as the Joint Spanish-Namibian Commission of Cooperation. SCOR is strongly based on international and multidisciplinary collaboration towards oceanographic research. The South Atlantic Mid-oceanic ridge and related seamount chains are prominent structures of the deep seafloor that lie mostly outside EEZs of coastal countries, implying that commercial exploration, conservation and research initiatives have essentially been multinational and/or international enterprises. In that sense SCaR is believed to be a natural organization to promote a continuing international CoML-derived scientific initiative focused on expanding our understanding of these remote areas of the deep ocean. The South Atlantic will be the location focus but concepts and ideas that result from this initiative will be applicable and comparable with other mid-ocean ridges of the planet.

3. Terms of Reference

- Produce a comprehensive and geo-referenced synthesis of published studies on biodiversity and oceanographic patterns associated to the South Atlantic Mid-Ocean ridge and

associated mountain chains (St. Peter's and St. Paul's Rocks, Walvis Ridge and Rio Grande Rise).

- Convene International Workshops to compile and analyze results produced by the first South Atlantic MAR-ECO cruise (November 2009) and the Trans-Atlantic Commission I (plankton diversity), and to publish a special volume in an internationally recognized peer-reviewed j ourna!.
- Coordinate the process of entry of South Atlantic Mid-Ocean ridge biodiversity records into Ocean Biogeographic Information System (OBIS - CoML).
- Promote networking activity to explore opportunities for continued field work on the South Atlantic and other oceans mid-ocean ridges and mountain chains. This activity will include: (a) to expand scientific collaboration principally among South America and African countries, (b) to identify suitable vessels that could be used for deep-water sampling in the South Atlantic, (c) to find the means to secure shiptime within the project time-schedule and (d) to form an international consortium that could combine marine research funds from several sources including those available in South Atlantic countries, other partner countries, international funds and the private sector.

4. Working Group Composition

Proposed members for the WG on Biodiversity Patterns of the South Atlantic Mid-Ocean Ridge

Name	Affiliation	Country	Expertise
Jose Angel Alvarez Perez *(proposed chair* of *the group)*	University of Vale do Itajaf Laboratory of Biological Oceanography	Brazil	Chair of the South Atlantic MAR-ECO project Steering Group Deep-water fishery Cephalopods
Andrey Gebruk	Shirshov Institute of Oceanology	Russia	Member of the MAR-ECO project Steering Group Benthic invertebrates
Jose Henrique Muelbert	Federal University of Rio Grande Department of Oceanography	Brazil	MAR-ECO PI Ichthyoplankton Physical-Biological Oceanographic Processes
Luiz Fernando Loureiro Fernandes	Federal University of Espirito Santo Department of Ecology and Natural Resources	Brazil	MAR-ECO PI Zooplankton
Malcolm Clark	National Institute of Water and Atmospheric Research	New Zealand	Member of the South Atlantic MAR-ECO project Steering Group Chair of the CenSeam project CoML Seamount ecology and fisheries
Marek Lipinski	National Marine Information and Research Centre Ministry of Fisheries and Marine Resources	South Africa	Cephalopods Demersal fish ecology
Patricio Arana	Escuela de Ciencias del Mar Universidad Catolica de Valparaiso	Chile	Deepwater fisheries Seamount ecology
Odd Aksel Bergstad	Institute of Marine Research	Norway	Chair of the MAR-ECO project Steering Group Demersal fish ecology

Ricardo Serrao Santos	Department of Oceanography and Fisheries University of Azores	Portugal	Member of the MAR-ECO project Steering Group Deepwater Fish
Ben Van Zyl	National Marine Information and Research Centre Ministry of Fisheries and Marine Resources	Namibia	Member of the South Atlantic MAR-ECO project Steering Group Executive Secretary SEAFO Deep-water fisheries

Other potential members or collaborators

Name	Affiliation	Country	Expertise
Debora Pires	Federal University of Rio de Janeiro National Museum	Brazil	Member of the South Atlan MAR-ECO project Steerin Group Deep-water corals
Johan Augustin	National Marine Information and Research Centre Ministry of Fisheries and Marine Resources	South Africa	Member of the South Atlan MAR-ECO project Steerin Group Deep-water fisheries
Andre O.S. Lima	University of Vale do Itajaf Laboratory of Applied Microbiology	Brazil	MAR-ECO PI Microbiology and Bioprospection
Luis Abelian	Instituto Oceanografico Espanol	Spain	Seamount ecology Deepwater crustaceans

2.3.6 Research Vessel Cruise Information Coordination

Proposal for a SCOR sponsored Working Group for Research Vessel Cruise Information Coordination

Abstract:
The goal of this SCOR working group is to greatly improve the amount and accuracy of research vessel cruise information by assigning this specific task to an international group of data professionals who will produce timely summaries of relevant ship operations in an easy-to-use format for use by the various systems described below. We will take advantage of existing meetings and conferences to convene our group, provide regular international cruise updates, disseminate these data in a compact, machine readable format, and publish a follow-up article in EOS or a similar publication describing the improvements in this information system.

Rationale
There are several efforts currently attempting at managing ship and cruise information:]COMMOPS, GO-SHIP, CCHDO, and POGO and numerous institutional web sites. The sheer number of systems trying to coordinate this meta information reflects the international demand for global and technical coordination regarding all ship/cruise related activities across programs.

While a substantial investment has been made in systems such as the POGO cruise database, only the technical components of such data repositories have been addressed and implemented. For the most part, these meta data are not augmented by information which accurately reflects the dynamic nature of research vessel logistics. The efforts to date have provided viable databases and web tools but have not consistently provided up-to-date specific cruise information such as those being exchanged in person at meetings or in email messages, which have not been captured and ingested by the current online cruise planning systems.

These meta data are essential in order to:

- Facilitate maintenance and operations of global arrays through logistics coordination when required.
- Further develop cooperation between programs (e.g. shared cruises, berths available, ship time).
- Identify future research cruises, and CTD data essential to intercomparisons for data quality control, in cooperation with the international initiatives, particularly to identify new regional deployment opportunities.
- Further develop Float/buoy donor programs
- Arrange retrieval of beached instruments when necessary.

Proposed Solution to lack of consolidated research vessel cruise information

The current group of systems addressed the technical barriers to providing such information, but collectively, they do not provide the manpower to collect and vet these meta data before they are disseminated by an online system. These online systems would be best served by a dedicated group of individuals from diverse regions who seek out ship cruise meta data through professional contacts during the first 12-18 months of official operation. While this group cannot provide all of the technical or logistical coordination necessary for a complete overhaul of existing databases, it can and should improve both the volume and accuracy of research vessel schedules and will provide this information in a simple but comprehensive format for inclusion in various national and international scheduling systems.

Practically such a group would:

- identify the key partners and information sources
- identify the different customers
- develop the backbone of a simple interoperable information system
- document the present and future needs

Terms of Reference

The goals of our proposed working group are to:

1. Leverage off of the activities already in progress by using and/ or enhancing existing cruise planning procedures and data formats as well as identifing the key information providers by institution, country and reglOn.
2. Facilitate effective communications and agreements between appropriate group members and these information providers to provide consistently updated, detailed and accurate cruise plans for international research groups including, but not limited to Argo, GO-SHIP, GEOSS, CLIVAR, GOOS, R2R and]COMMOPS.
3. Meet on a regular basis in person and online in order to organize these meta data and consolidate them into a format usable by consumers of these data.
4. Construct a prototype "mailbag" system by which information providers might provide these meta data utilizing a one-way asynchronous online procedure.
5. Publish a follow-up to the original EOS cruise planning database article describing our group's improvements to that online information system.

Timeline

If selected for funding, our group will need to meet without delay since the demand for these data already exceeds the supply. Two of these meetings will be held in the same calendar year to facilitate a fast, consistent start for the project.

Our first meeting will be held in conjunction with the 7th INMARTECH Meeting 19 - 23 January 2011 Wellington, New Zealand. This meeting will focus on making the international

ship operators aware of our working group, as well as allowing us to conveniently invite representatives in attendance from other organizations who work with similar information such as the newly formed Rolling Deck to Repository (R2R) initative sponsored by NSF.
Our second working group meeting will be held in October 2011 during the WCRP Open Science Conference 2011 in Denver, Colorado USA. At this meeting, the group's efforts should be concentrated on finalizing a meta data exchange format, reviewing agreements between the group and ship operators, and quantifying the increase cruise information since our inception.

By our third and final meeting, perhaps the EGU 2012 or 2013 meeting, we should be well underway and should have significant progress, worthy of a poster at such a meeting followed up by an EOS-type publication describing the group's contributions to a much improved cruise planning online system that serves the global ocean research community.

Working Group Composition

1. Steve Diggs (USA / chair)
2. Mathieu Belbeoch - JCOMMOPS (International)
3. Patrick Gorringe (Australia / IMOS)
4. Tim Boyer (USA / NODC)
5. Toste Tanhua (Germany)
6. Loic Petit de la Villeon (France)
7. Norio Baba (JODC)
8. Uday Baskhar (India)
9. Lesley Rickards (UK)
10. Ursula Von St Ange (South Africa)

Associates

- Bob Keeley (Canada)
- SOOP Committee (Ann Thresher)
- Candyce Clark
- Doug White (Delaware)
- Bert Thompson
- Esmee Van Wijk (CSIRO)
- Bob Key (Princeton)
- Benjamin Pfiel (CARBO-Ocean / Norway)
- Shao Hua Lin (China)

Travel

Meetings should be held on an annual basis, with possible bi-monthly online meetings which have already proven effective with many other similar working groups.